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JOURNAL OF PALEONTOLOGY

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OSTRACODA FROM MIDDLE DEVONIAN WINDOM BEDS IN WESTERN NEW YORK

FRANK M. SWARTZ AND STEVEN S. ORIEL
The Pennsylvania State College, and Yale University

ABSTRACT—Collections furnished by E. R. Eller from the Windom shale of the Middle Devonian, late Hamilton Moscow formation of New York, have furnished specimens of 22 ostracode species of which 18 are new and 3 indeterminate. The species, listed elsewhere in the paper, are distributed through 15 genera and 10 families. Examples of *Quasillites* Coryell and Malkin and of *Euglyphella* Warthin are most numerous. *Ctenoloculina* Bassler, *Ctenobolbina* Ulrich, and *Jenningsina* Coryell and Malkin also are represented by significant species. The members of all these genera are closely related to Ostracoda described by Coryell and Malkin from the pre-Windom Hungry Hollow beds of the Hamilton of Ontario; but *Ulrichia* Jones, *Bollia* Jones and Holl, *Richina* Coryell and Malkin, and *Ponderodictya* Coryell and Malkin, which are important in the Hungry Hollow fauna, are not represented in the collections from the Windom.

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INTRODUCTION AND ACKNOWLEDGMENTS

IN WASHING residues from Middle Devonian strata of western New York for scolecodont remains, Dr. E. R. Eller (1941) of the Carnegie Museum discovered a fine assemblage of ostracode specimens, and kindly sent them to the senior author for study and description. The type material will be deposited with the Carnegie Museum in Pittsburgh.

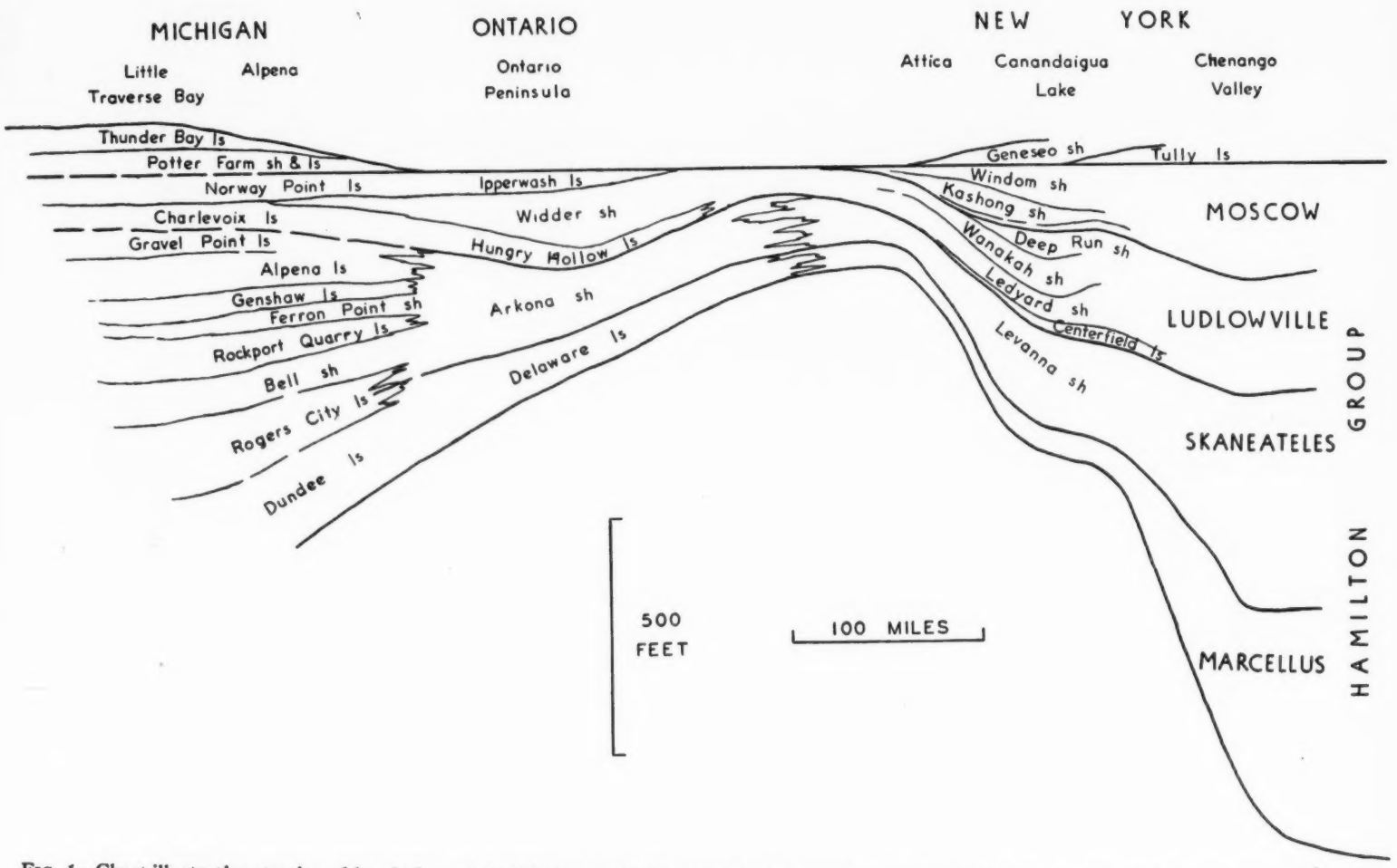

FIG. 1—Chart illustrating stratigraphic relations of the Windom shale. The described Ostracoda were obtained by E. R. Eller in the Windom beds in the general vicinity of Attica, western New York. Thicknesses are approximate.

Most of the work for the present paper was completed while the junior author was a graduate student at the Pennsylvania State College in 1946.

Laboratory facilities were provided by the School of Mineral Industries of the Pennsylvania State College. Dr. Otto H. Haas was particularly kind in aiding the junior author to make comparisons with some of the ostracode type material at the American Museum of Natural History.

STRATIGRAPHIC HORIZON AND LOCALITIES

The ostracode collections loaned by Dr. Eller were found in residues obtained by acid treatment of an impure, concretionary limestone, lying near the base of the Windom member of the Moscow formation.

The Moscow formation constitutes the upper part of the Middle Devonian Hamilton group, and is composed, in westernmost New York, of the Windom shale, above, underlain by the Kashong shale and in turn the thin Menteth or the Portland Point limestone. The Moscow beds lie above the Ludlowville formation of the Hamilton, and below the Geneseo of the latest Middle Devonian or earliest Upper Devonian. Farther east, the Tully limestone appears between the Moscow and the Geneseo. (See fig. 1, and Cooper, 1930.)

Most of the specimens of the collection were found along Bowen Brook, north of Attica, in the area of the Attica quadrangle, at about 78° 17½′ west longitude, 42° 55′ north latitude. (See fig. 2.) A few additional specimens came from Murder Creek, in the same quadrangle, near Darien, at about 78° 21′ west longitude, 42° 55′ north latitude. Several specimens were collected on White Creek in the Batavia quadrangle, near East Bethany at about 78° 4½′ west longitude, 42° 56′ north latitude, as well as along Little Beards Creek, near Leicester, in the Caledonia quadrangle, at about 78° 54′ west longitude, 42° 47′ north latitude.

CHARACTER OF THE SPECIMENS

The fossil specimens furnished from the Windom by Dr. Eller are siliceous and pyritic replacements of the original carapace material. Many of them preserve the shell ornament in beautiful detail. Some, of course, have suffered from abrasion and other damage so that the more minute features of the surface are imperfectly shown; the edges likewise may be incomplete, thereby obscuring the contact relations of the valves. Especially in the pyritic replacements, crystal growth tends to coarsen and thus obliterate the tinier structures of both surface and margin.

Adductor scars have been sought; but their details, and even their general form and location, are obscure in all save a few of the valves. Hinge structures and overlap relations similarly remain to be established in many of the species.

LIST OF SPECIES

The Windom Ostracoda described in the present paper include 19 named species, and 3 forms of unassigned specific relationships, distributed through 15 genera and 10 families. All but one of the named species are considered to be new. For the most part, the species clearly belong in established genera as currently understood. The generic allocation of *Jonesina* (*?*) *sinistralis*, however, remains uncertain since the single left valve on which *sinistralis* is based has a strong umbo that is abnormal for *Jonesina*. Due to lack of knowledge about the right valve it does not seem wise to propose a new generic category for this species. There likewise is question about the two species tentatively assigned to the Ordovician genus, *Punctaparchites*.

The list of described Windom Ostracoda is as follows:

Family Aparchitidae Jones
- Genus *Punctaparchites* Kay
  - *Punctaparchites* (*?*) *paralobatus* Swartz and Oriel, n. sp.
  - *Punctaparchites* (*?*) *sulcellus* Swartz and Oriel, n. sp.

Family Primitiidae Ulrich and Bassler
- Genus *Punctoprimitia* Stewart and Hendrix
  - *Punctoprimitia subaequalis* Swartz and Oriel, n. sp.

Family Hollinidae Swartz
- Genus *Ctenobolbina* Ulrich
  - *Ctenobolbina windomensis* Swartz and Oriel, n. sp.
  - *Ctenobolbina longisulcata* Swartz and Oriel, n. sp.
- Genus *Ctenoloculina* Bassler
  - *Ctenoloculina acanthophora* Swartz and Oriel, n. sp.

Family Kirkbyidae Ulrich and Bassler
- Genus *Amphissites* Girty
  - *Amphissites lacrimosus* Swartz and Oriel, n. sp.

FIG. 1—Chart illustrating stratigraphic relations of the Windom shale. The described Ostracoda were obtained by E. R. Eller in the Windom beds in the general vicinity of Attica, western New York. Thicknesses are approximate.

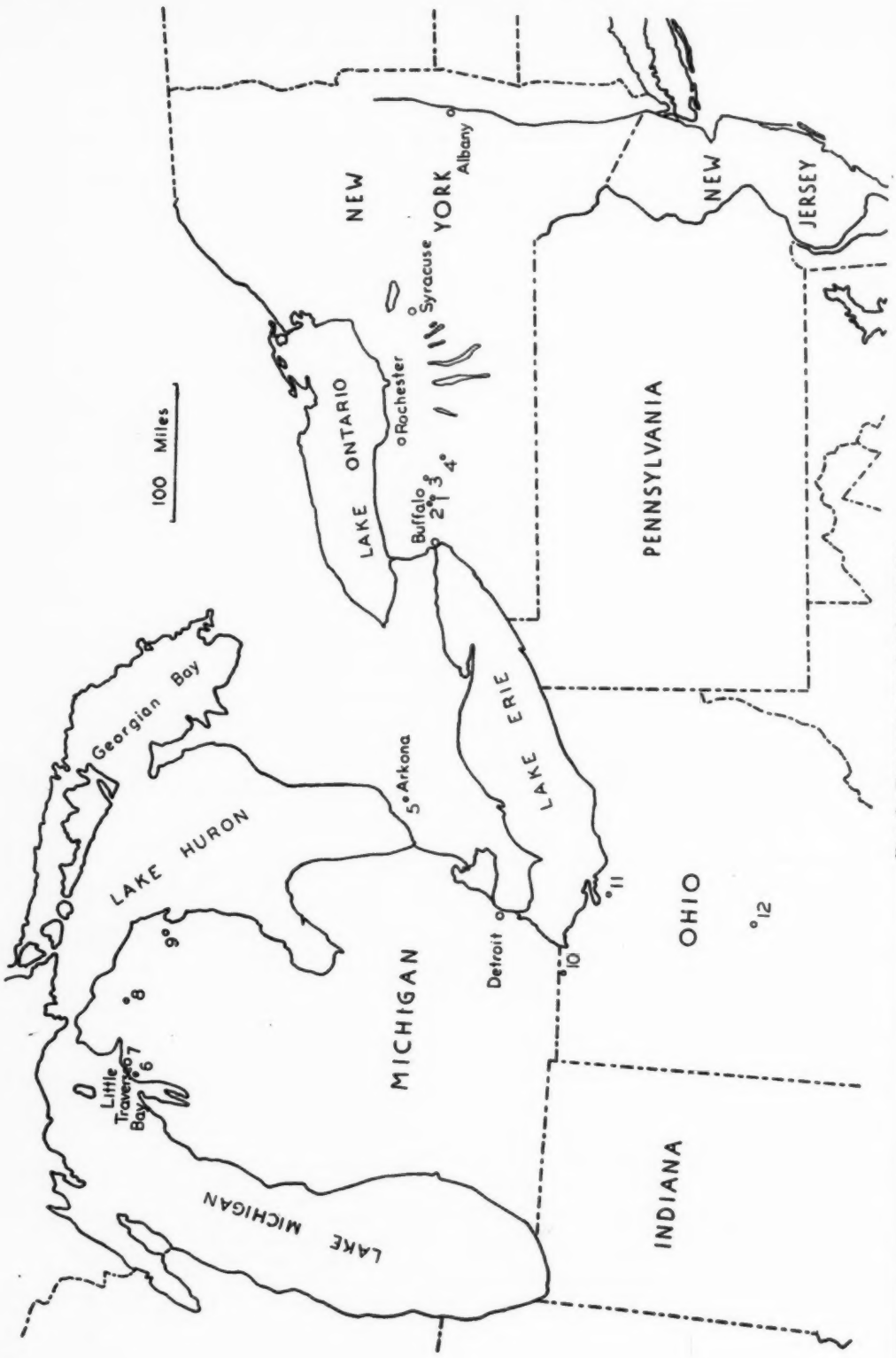

FIG. 2.—See next page for description

Family Kloedenellidae Ulrich and Bassler
Genus *Jonesina* Ulrich and Bassler
Jonesina (?) sinistralis Swartz and Oriel, n. sp.
Family Quasillitidae Coryell and Malkin
Genus *Quasillites* Coryell and Malkin
Quasillites lobatus Swartz and Oriel, n. sp.
Quasillites sp.
Quasillites ornatus Swartz and Oriel, n. sp.
Quasillites subobliquus Swartz and Oriel, n. sp.
Quasillites binodosus Swartz and Oriel, n. sp.
Genus *Spinovina* Coryell and Malkin
Spinovina sp.
Genus *Jenningsina* Coryell and Malkin
Jenningsina divaricata Swartz and Oriel, n. sp.
Family Thlipsuridae Ulrich
Genus *Thrallella* Stewart and Hendrix
Thrallella cristata Swartz and Oriel, n. sp.
Family Ropolonellidae Coryell and Malkin
Genus *Euglyphella* Warthin
Euglyphella numismoides Swartz and Oriel, n. sp.
Genus *Bufina* Coryell and Malkin
Bufina sp.
Family Bairdiidae Sars
Genus *Tubulibairdia* Swartz
Tubulibairdia windomensis Swartz and Oriel, n. sp.
Genus *Lucasella* Stewart
Lucasella cf. *cavanifera* Stewart and Hendrix
Lucasella sulcella Swartz and Oriel, n. sp.
Family Cypridae Zenker
Genus *Condracypris* Roth
Condracypris subovalis Swartz and Oriel, n. sp.

FIG. 2—See next page for description

COMPARISONS WITH OTHER OCCURRENCES

Middle Devonian ostracodes from central and eastern parts of North America have been described by a considerable number of authors, including Jones (1889, 1890), Ulrich (1891, 1900), Van Pelt (1933), Warthin (1934), Coryell and Malkin (1936), Stewart (1936), Turner (1939), Bassler (1941), Swartz and Swain (1941), and Stewart and Hendrix (1945).

In these Middle Devonian assemblages, the closest relationships with the Windom faunule are found among the ostracodes described by Coryell and Malkin (1936) from the coral zone of the basal part of the Widder beds of the Hamilton group, about one and one-half miles east of Arkona, Lambton County, Ontario. The coral zone has subsequently been included, along with the underlying encrinal limestone, in the Hungry Hollow formation by Cooper and Warthin (1941). The Widder and Hungry Hollow beds are believed to be equivalent to parts of the Ludlowville formation of the Hamilton group of western New York, and thus to be appreciably older than the Windom. (See fig. 1.) Hence, it is not at all surprising to find that though many of the genera found in the Windom are also represented in the Hungry Hollow limestone, and though several of the members of the two collections are very closely related, the species are in general distinct.

Evidence of close affinity of the two faunal

FIG. 2—Map showing (1–4) localities from which Eller obtained the Hamilton Ostracoda described in the present paper. Relationships with Hamilton Ostracoda of Ontario (5) are discussed, and in the descriptions of species comparisons are made with some ostracodes of Middle Devonian beds of Michigan (6–9), and of Middle to earliest Upper Devonian strata of Ohio (10–12).

1– 5 Localities of Hamilton group Ostracoda in New York and Ontario
1. Bowen Brook near Attica, New York
2. Murder Creek near Darien, New York
3. White Creek near East Bethany, New York
4. Little Beards Creek near Leicester, New York
5. Arkona, Ontario (Coryell and Malkin)

6– 9 Localities of Middle Devonian Ostracoda in Michigan (Warthin)
6. Northwestern Charlevoix County, Michigan
7. Southwestern Emmet County, Michigan
8. Cheboygan County, Michigan
9. Alpena County, Michigan

10–12 Localities of Middle and earliest Upper Devonian Ostracoda in Ohio
10. Silica shale, Lucas County, Ohio (Stewart)
11. Plum Brook shale, Erie County, Ohio (Stewart and Hendrix)
12. Olentangy shale, Franklin and Delaware counties, Ohio (Stewart and Hendrix)

groups is found in the abundance, in both, of species of *Euglyphella* and *Quasillites*. *Euglyphella numismoides* of the Windom is reminiscent of *E. sigmoidalis* (Jones), though the latter form as figured from the Hungry Hollow beds differs in details of its furrows. *Quasillites subobliquus* of the Windom is very close to *Q. obliquus* Coryell and Malkin

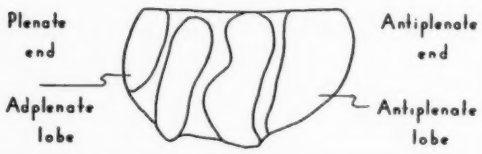

FIG. 3. Diagram of a valve of *Ctenoloculina acanthophora*. This is a "left-plenate" valve in the sense that the plenate end lies to the left of the observer. The plenate end is by definition the end toward which the "swing" of the shell is directed, and which tends to be plenate or full because of the greater area of the region extending beyond the hinge. The degree of plenation is a composite effect of relative height of the ends, relative projection beyond the limits of the hinge, and relative fullness of the ventro-adplenate as compared to the ventro-antiplenate parts of the margin.

Dimorphic chambers occur in *Ctenoloculina* in the ventro-adplenate region of each valve; hence if these structures mark the posterior end of the shell, the figure represents a right valve. If, on the other hand, the deeper, upper part of the median sulcus was the location of adductor attachment, and if the adductor was antero-median in position as it tends to be in modern Ostracoda, then the figured valve would be a left valve.

The adjectives adplenate, meaning toward the plenate end, and antiplenate, meaning away from the plenate end, can be used to distinguish the lobes, sulci, and other features of the valve.

of the Hungry Hollow; *Q. lobatus* of the Windom suggests *Q. obliquus* to some degree, and *Q. ornatus* is reminiscent of *Q. fordei* of the Hungry Hollow. *Jenningsina divaricata* of the Windom is another species with striking ornament, and is closely related to *J. catenulata* of the Hungry Hollow. *Ctenoloculina acanthophora* of the Windom may prove to be identical with the specimens from the Hungry Hollow identified as *C. cicatricosa*, though it differs more clearly from the holotype of *cicatricosa* which came from Norway Point beds in Michigan. A single valve of *Bufina* from the Windom, which was unfortunately destroyed before it could be figured or described, was suggestive of *B. elongata* of the Hungry Hollow.

On the other hand, other genera that furnish important elements of the Hungry Hollow faunule, especially *Ulrichia*, *Bollia*, *Richina*, *Ponderodictya*, and *Cavellina*, are not now known to be represented in the Windom. The Hungry Hollow species of *Ulrichia*, *Bollia*, and *Richina* find close counterparts downward into Onondaga horizons, so that their present apparent disappearance in the Windom should, if confirmed by further collecting, take on considerable stratigraphic importance.

In contrast, the new *Thrallella cristata* represents the occurrence in the Windom of a genus that hitherto had been reported only in the post-Hamilton Olentangy shale. (See Stewart and Hendrix, 1945.) Rarity of the two species of the genus reduces their present stratigraphic significance.

The scolecodonts discovered by Dr. Eller (1941) in the Windom shale include four species known also in both Widder and Olentangy beds in Ontario.

ORIENTATION TERMINOLOGY

In descriptions of Middle Devonian Ostracoda comparable to the more or less straight-backed species described in the present paper, as in the case of the straight-hinged Paleozoic groups in general, it has been common practice to follow the views advanced by Ulrich and Bassler (1908, 1923), and to employ anterior-posterior orientations based on the supposition of posterior direction of the "swing" of the shell.

Though they are inclined to accept the arguments for posterior direction of swing in some groups, the writers favor as plausible though not soundly established the view that in the Ropolonellidae and Quasillitidae as in the Kloedenellidae the swing of the shell is forward in terms of the former animal inhabitant. They hence have been faced with the possibility of employing, for conformity to common practice, orientations that they think are probably unsound; or of using contrary orientations that they feel are somewhat more plausible though not yet satisfactorily established, even

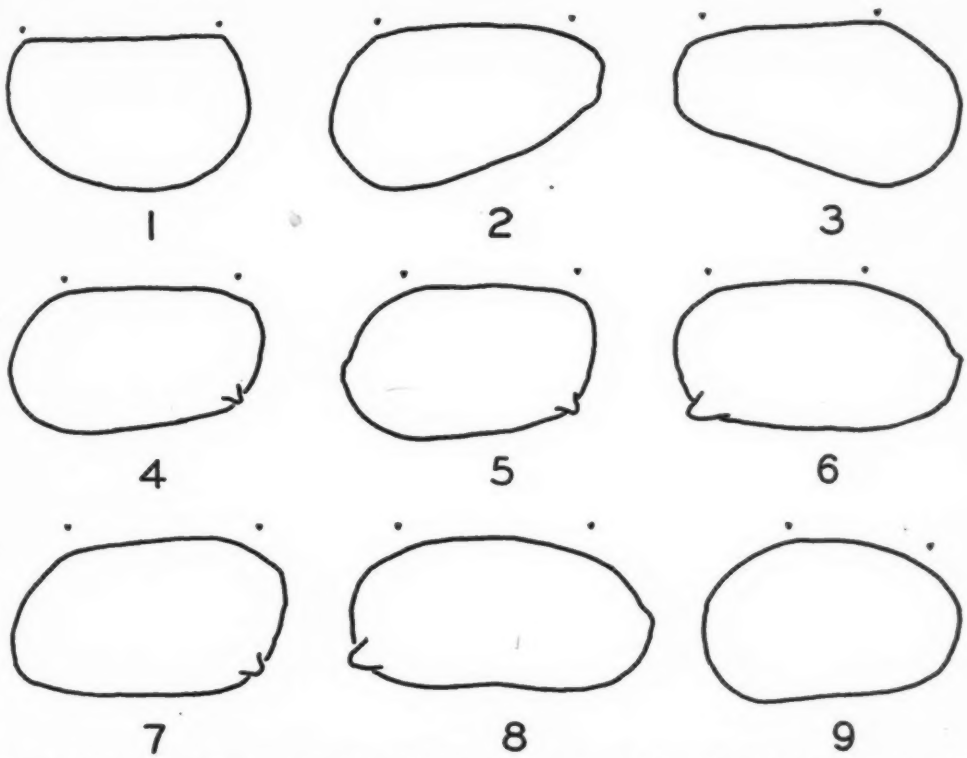

FIG. 4. Valve outlines illustrating varying degrees and characters of plenation. Dots indicate approximate limits of the hinge; the relative size of the areas extending beyond the limits of the hinge, as well as direction of swing, must be considered in judging plenation.

1, Right-plenate valve of *Ctenobolbina windomensis*, a straight-backed ostracode with well-marked plenation.

2, 3, Left-plenate and right-plenate valves of *Euglyphella numismoides*, showing extreme plenation. Dimorphic structures are not known in *Euglyphella* and other Ropolonellidae. Valves like that represented in 2 have been classed as right valves by authors following the thesis of "backward swing"; the writers favor the view that this is a left valve in view of the tendency of later Ostracoda to be anteriorly plenate.

4–6, Two left-plenate and one right-plenate valves of *Quasillites ornatus*. Opposing valves of *Quasillites* are dissimilar in shape, and swing is more marked in the left-plenate than in the right-plenate valve.

7, 8, Left-plenate and right-plenate valves of *Quasillites lobatus*. As in *Q. ornatus*, swing is better defined in the left-plenate than in the right-plenate valve.

9, Left-plenate valve of *Thrallella cristata*. Strong plenation of the end to the observer's left results more from comparative extension beyond limits of the hinge than from comparative height of the ends. In modern Ostracoda of comparable valve-outline and hinge position, the valve of this outline is the left valve.

though these may prove incorrect and will trouble workers making comparisons of the new species with their known relatives.

Instead of following either of these courses the writers have chosen to use as an experiment the "plenate" terminology suggested recently by the senior author (Swartz, 1945) as a vehicle for objective discussion of orientation problems. The term, plenate end, was proposed for the end of the ostracode shell toward which the swing is directed, because this end tends to be relatively "full" either in height, or in extension beyond the hinge, or in both respects. The opposing end can then be termed the "antiplenate end"; features toward the one or other end are "adplenate" or "antiplenate"; the valve having the plenate end to the observer's

left as seen in lateral view or in a photograph is the "left-plenate" valve; where the plenate end in such view is to the right the valve is "right-plenate." The proposed usage of the terms is further illustrated in figures 3 and 4.

As applied to the Ostracoda described in the present paper, the "plenate" terminology has seemed to the writers to give some promise of usefulness, though obviously the question of its value must depend upon whether other workers find it an aid or a hindrance. In most cases the terminology rests on definite realities.

It must not be supposed that the writers are suggesting the "plenate" terminology for common use in systematic descriptions. "Anterior" and "posterior," and "right valve" and "left valve" are far more desirable terms wherever common agreement can be attained. The "plenate" terminology is at best a reasonably objective adjunct, that may be useful in discussions of orientation problems, and in systematic descriptions where the data for orientation remain distinctly inconclusive and practice is liable to be unstable. An especial value arising from attention to "plenation" may come from light thrown on questions of morphology of Paleozoic Ostracoda (Swartz, 1945).

Though the "plenate" terminology has been employed in many of the systematic

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EXPLANATION OF PLATE 79

All illustrations approximately ×35 unless otherwise indicated. All specimens are from the Windom beds, Bowen Brook, N. Y.

FIGS. *1, 2—Punctaparchites* (*?*) *paralobatus* Swartz and Oriel, n. sp. *1*, Lateral view of holotype left-plenate valve. *2*, A smaller, imperfect right-plenate valve showing slight sulcation and surface pitting. (p. 550)

3—Punctaparchites (*?*) *sulcellus* Swartz and Oriel, n. sp. Lateral view of holotype left-plenate valve showing subequal ends, relatively distinct pits. (p. 550)

4, 5—Punctoprimilia subaequalis Swartz and Oriel, n. sp. *4*, Lateral view of holotype "right" valve. *5*, Dorsal view of same valve showing strong convexity. (p. 550)

6—Ctenobolbina windomensis Swartz and Oriel, n. sp. Lateral view of holotype right-plenate valve. (p. 551)

7—Ctenobolbina longisulcata Swartz and Oriel, n. sp. Lateral view of incomplete holotype, right-plenate valve, showing the long sulcus and the pitted pustules. (p. 552)

8–14—Ctenoloculina acanthophora Swartz and Oriel, n. sp. *8*, Lateral view of holotype left-plenate valve showing surface features. *9*, Interior view of left-plenate valve, reflecting only larger external features. *10*, Lateral view of another left-plenate valve showing relatively narrow medio-antiplenate lobe, and spinules on median lobes. The margin is imperfect. *11*, Interior view of fragment of right-plenate female valve, showing brood chambers. *12–14*, Views, ×45, of fragment of ventral part of a male left-plenate valve, preserving the spinose, ventral prolongations of the two median lobes. In *13*, the fragment is tilted to show tiny spinules along ventral edge; *14* is internal view of fragment showing pits reflecting the external spinose projections, and two narrow grooves paralleling the ventral margin. (p. 553)

15—Amphissites lacrimosus Swartz and Oriel, n. sp. Lateral view of holotype right-plenate valve. Specimen now less perfect than when photographed. (p. 553)

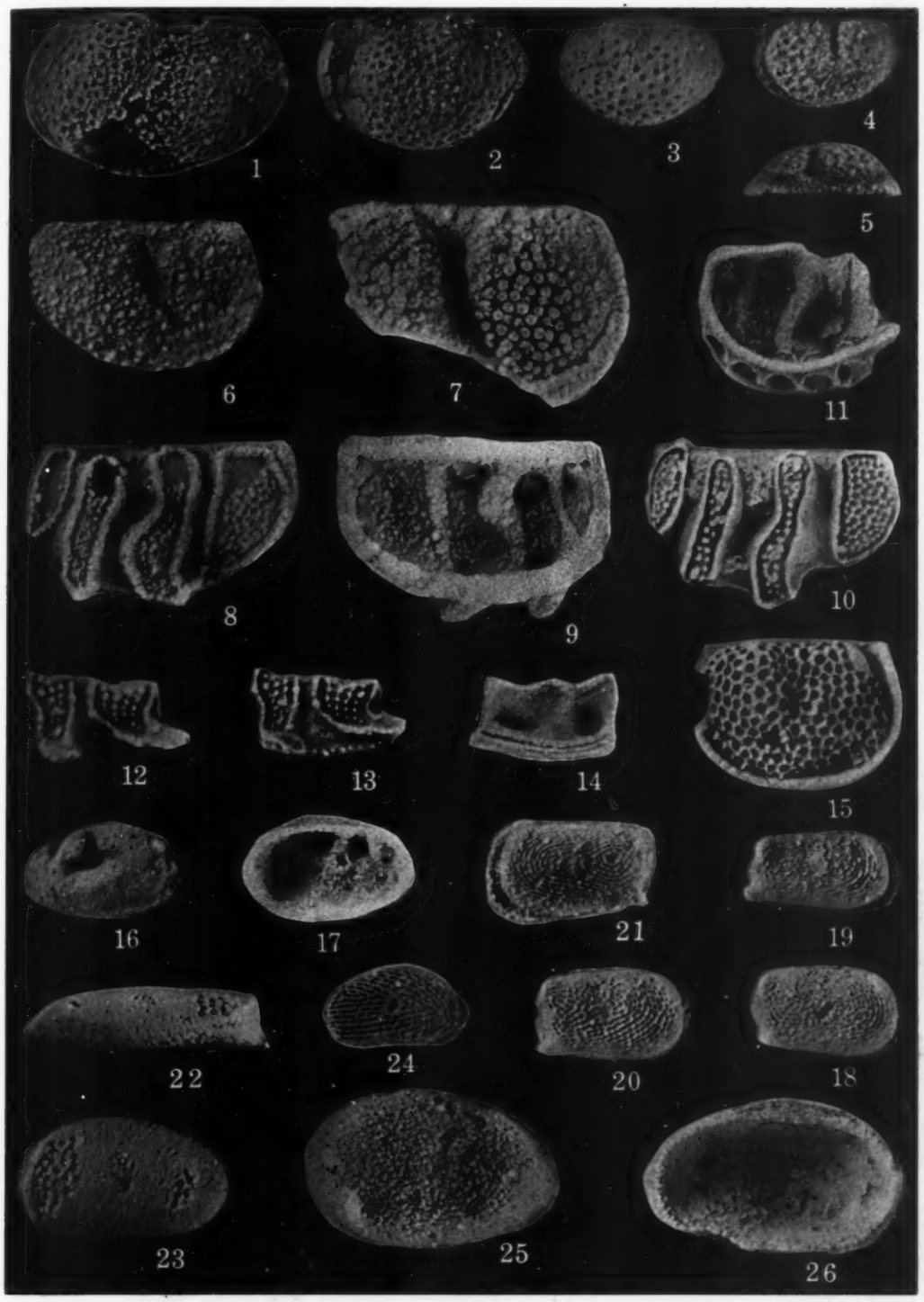
16, 17—Jonesina (*?*) *sinistralis* Swartz and Oriel, n. sp. *16*, Lateral view of holotype left valve, showing strongly convex dorsal margin. *17*, Interior view of same valve showing character of umbonation and internal features. (p. 554)

18–21—Quasillites binodosus Swartz and Oriel, n. sp. *18*, Lateral view of holotype right-plenate valve; submedian dark area is hole in specimen. *19*, A more elongate right-plenate valve showing concentric character of antiplenate ornament; the ventro-antiplenate region is unusually protuberant. *20*, Another right-plenate valve showing reticulate ornament more clearly. *21*, Lateral view of a left-plenate valve showing exceptionally wide adplenate flange, and concentrically arranged ridges in antiplenate half. Reference to *binodosus* might be questioned. (p. 559)

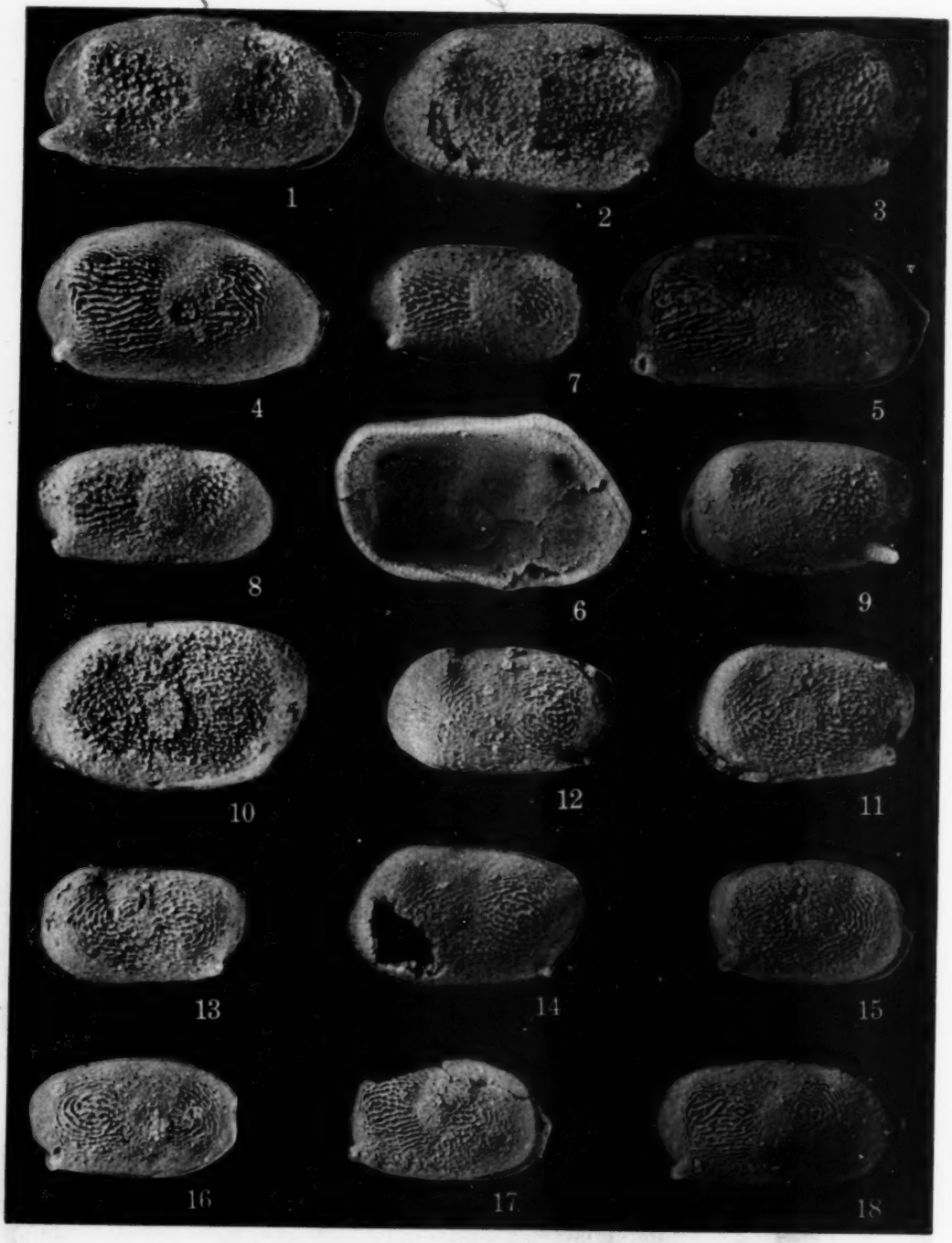
22, 23—Thrallella cristata Swartz and Oriel, n. sp. Dorsal view of holotype left-plenate valve showing steep, concave adplenate slope, and lateral view showing shape and ornament. (p. 561)

24—Jenningsina divaricata Swartz and Oriel, n. sp. Lateral view of holotype right-plenate valve. (p. 561)

25, 26—Spinovina sp. Lateral and interior views of valve showing, in *26*, the dorsal umbonation, and imperfect ventral edge. (p. 560)



Swartz and Oriel, Windom Ostracoda



Swartz and Oriel, Windom Ostracoda

descriptions of the present paper, it is not being used in most of the descriptions being prepared concurrently by the senior author for several collections of Silurian Ostracoda. Only a few of the Windom species represent families in which dimorphic features are now recognized; the Silurian forms, on the contrary, include numerous Beyrichiidae and Zygobolbidae, in which the ventro-adplenate position of the dimorphic pouch strongly supports the view that the plenate end is the posterior one, as well as Kloedenellidae in which the antiplenate dimorphic structures suggest that the plenate end is anterior. In Leperditiidae, the posterior position of the plenate end is well established by the antiplenate locations of the eye tubercle and especially of the adductor scar. The orientations of these Ostracoda are thought to be well enough established to justify use of "anterior" and "posterior" in systematic descriptions.

SYSTEMATIC PALEONTOLOGY

Order OSTRACODA Latrielle
Family APARCHITIDAE Jones
Genus PUNCTAPARCHITES Kay, 1934

The genus *Punctaparchites* was proposed by Kay (1934) for several Ordovician species that were described as follows:

> Valves small, equal; outline oval or suboval, dorsally truncated; hinge straight or slightly concave; surface regularly convex, with numerous distinct pits. Contact plane, valves exactly equal.

Two species of the Windom fauna are suggestive of the members of this Ordovician genus in their aparchitid form, obscurely lobate surface, and punctate ornament. However, they differ from the genotype, *Punctaparchites rugosus* (Jones) in their less ovate, more equal ended outline, the more gentle terminal slopes of the valves, and in presence of an obscure dorso-submedian depression or sulcus. The observed material

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EXPLANATION OF PLATE 80

All illustrations approximately ×35. All specimens are from the Windom beds, Bowen Brook, N. Y.

FIGS. *1–8*—*Quasillites lobatus* Swartz and Oriel, n. sp., showing variations in individual specimens which make classification difficult. *1*, Lateral view of holotype right-plenate valve showing convex dorsal margin, adplenate cusp, and rounded antiplenate cardinal bend. *2*, *3*, Lateral view of a left-plenate valve and fragment of another, showing reticulate ornamentation, and the difference in outline including the more prominent cardinal bends. *4*, Right-plenate valve with unusually convex dorsal margin and narrowly curved plenate margin. The finely preserved ornament is not as coarse as in *1*. This specimen would have been used as the holotype of *lobatus*, were it not for the exceptional convexity of the dorsal margin. *5*, A large right-plenate valve with outline as in *1*, ornament as in *4*. Dorsal half of antiplenate margin is incomplete but has been restored in the photograph. *6*, Interior view of a fractured left-plenate valve. *7*, *8*, Two smaller right-plenate valves believed to be immature molts of the species. (p. 556)

9—*Quasillites* sp. A left-plenate valve that may prove to be an immature example of *lobatus*, though the ornamented areas are less extensive than in the presumed youthful valves figured in *7* and *8*. (p. 557)

10—*Quasillites subobliquus* Swartz and Oriel, n. sp. Lateral view of holotype left-plenate valve. The specimens shown in *4* and *5* may prove to belong in this species rather than in *lobatus* as based on *1*. (p. 559)

11–17—*Quasillites ornatus* Swartz and Oriel, n. sp. *11*, Lateral view of holotype left-plenate valve showing adplenate cusp, nearly straight dorsal margin, and whorl-like arrangement of the antiplenate ornament. *12–14*, Left-plenate valves showing slight variation in outline and ornament. In *12* the specimen is a pyritic replacement; in *13*, the whorl of the antiplenate ridges is well developed; in *14*, ornament is unusually limited in extent. *15–17*, Right-plenate valves showing the more convex dorsal margin. In *16*, ornament is lacking in a relatively large median region; in *17* the adplenate rim and cusp are well preserved. (p. 558)

18—*Quasillites* cf. *lobatus* Swartz and Oriel, n. sp. Lateral view of right-plenate valve questionably referred to the species. The specimen lacks the adplenate ridge-like swelling and adjacent depression, and the dorso-antiplenate swelling is very weak. However, the general outline and extent of ornamentation conforms to the more finely-ridged specimens here included in *lobatus*, and the valve may be an immature example of these members of the species. (p. 556)

does not show whether the valves are "exactly equal." The new *paralobatus* and *sulcellus* are tentatively referred to *Punctaparchites;* but with the reservation that close generic relationship with the Ordovician genotype remains to be established.

PUNCTAPARCHITES (?) PARALOBATUS Swartz and Oriel, n. sp.
Plate 79, figures 1, 2

Carapace subovate in lateral view, truncated dorsally by the straight hinge which is about three-fourths of maximum length. Cardinal angles sharp, obtuse. Terminal margins rounded, fullest at midheight; plenate end somewhat higher than the other. Ventral margin convex. Maximum height is about three fifths of length and lies just adplenately to midlength. Hinge simple, in so far as ascertained; contact margins lie in a plane; overlap probably inconspicuous.

Surface of valve strongly convex. In terminal view, valve outline is semielliptical, the slopes to dorsal and ventral margins steep. Outline in dorsal view subtrapezoidal, the summit flattened; antiplenate slope slightly concave; adplenate slope gently convex; maximum convexity equals about one-third of valve length and lies one-third distance from plenate margin. In the upper third of valve, a low, poorly defined lobe-like swelling lies on the adplenate side of the obscure dorso-submedian sulcus.

Surface marked by numerous rounded, deep puncta that are irregularly arranged, the spacing fairly close. These puncta disappear on the terminal slopes.

The dimensions of the holotype valve are length 1.08 mm., height 0.68 mm., maximum convexity 0.43 mm.

Relationships.—Punctaparchites (?) paralobatus is closely related to *P. sulcellus*, but can be distinguished by the greater inequality in height of the ends, the more numerous puncta, and the dorso-adplenate swelling.

Occurrence.—Two valves found in the Windom beds at Bowen Brook, near Attica, New York.

PUNCTAPARCHITES (?) SULCELLUS Swartz and Oriel, n. sp.
Plate 79, figure 3

Carapace subelliptical to subpentagonal in lateral outline, truncated dorsally by hinge margin which is about two-thirds of greatest length. Cardinal angles obtuse. Terminal margins rounded, subequal; ventral margin convex, fullest on adplenate side of midlength, where the maximum height of carapace is not quite two-thirds of length. Contact margin lies in a plane; overlap probably inconspicuous.

Surface of valve strongly convex. In end view, the greatest convexity is median, the summit broadly rounded, the slopes to the dorsal and ventral margins steep, with a slight angulation near ventral edge. In dorsal view, the valve outline is subtrapezoidal, the summit flattened, with the greatest convexity slightly antiplenate to midlength; the antiplenate slope is slightly concave; an obscure, dorso-submedian sulcus extends about one-third to two-fifths distance from dorsal to ventral margin; the sulcus is very weak in the holotype, a little better defined on another example. Surface is marked by round, deep, distant, irregularly arranged puncta that become weak or disappear on the terminal slopes and near the hinge.

The holotype valve measures length 0.74 mm., height 0.47 mm., convexity 0.24 mm.

Relationships.—Punctaparchites (?) sulcellus is smaller and more equal-ended than *P. (?) paralobatus*, with fewer and more distant puncta.

Occurrence.—Two valves from Windom beds at Bowen Brook, New York.

Family PRIMITIIDAE Ulrich and Bassler
Genus PUNCTOPRIMITA Stewart and Hendrix 1945

PUNCTOPRIMITIA SUBAEQUALIS Swartz and Oriel, n. sp.
Plate 79, figures 4, 5

Carapace small, tumid; outline subovate in lateral view, truncated dorsally by straight hinge which is about four-fifths of greatest length; "anterior" cardinal angle obtuse, inconspicuous; "posterior" cardinal

angle sharp, nearly a right angle. "Anterior" margin more narrowly rounded than the other. Ventral margin moderately convex in outline, rounding subequally into the ends.

Valve in terminal view strongly convex, subsemicircular in outline, the maximum convexity submedian. In dorsal view, outline semiovate, the maximum convexity one-third from "posterior" margin; surface rises rather steeply from terminal margins; a shallow submarginal groove sets off a wide border paralleling the "posterior" margin.

Median sulcus is narrow, subvertical, lies just "anterior" to midlength, and extends nearly halfway from dorsal to ventral margin; ventral extremity of sulcus not umbilicate. Elevated portions of surface are marked by deep, distant pits, more numerous in area "posterior" to sulcus.

Length 0.60 mm., height 0.35 mm., convexity of valve 0.22 mm.

Relationships.—Subaequalis is closely related to *Punctoprimitia punctata* (Turner, 1939), but the ends of the carapace are not so unequal in height, the ventral margin is more convex in outline, the sulcus is narrower and is not umbilicate at its ventral extremity. *P. simplex* (Stewart, 1936) was originally described and illustrated as being smooth, and was figured as having a border along the free margins. Valves subsequently figured as *P. simplex* by Stewart and Hendrix (1945) are obscurely punctate. Some of these seeming differences may disappear with further studies of *punctata* and *simplex*, as well as of *subaequalis*.

"Anterior" and "posterior" are used in the description of *subaequalis* in the sense employed by Turner (1939), Stewart (1936), and Stewart and Hendrix (1945). The median sulcus lies closer to the "anterior" than to the "posterior" end, and the "anterior" angle is slightly more obtuse than is the "posterior" angle. The direction of "swing" of the valve results from the location of the greatest height. It appears probable to the senior author, judging from the position of the sulcus and of the more obtuse angle, that the direction of swing is reversed in *Punctoprimitia subaequalis* as compared to such forms as *Ctenobolbina windomensis* (see Plate 79, figs. 4 and 6), and that the end in *subaequalis* made plenate by the position of greatest height actually corresponds to the antiplenate end of *windomensis*. Thus "anterior" and "posterior" have been employed because, if the direction of swing is abnormal as suspected, the "plenate" terminology will not clarify comparative orientations.

Occurrence.—Two "right" valves found in Windom beds at Bowen Brook, near Attica, New York.

Family HOLLINIDAE Swartz
Genus CTENOBOLBINA Ulrich 1890
CTENOBOLBINA WINDOMENSIS Swartz and Oriel, n. sp.
Plate 79, figure 6

Carapace subovate in lateral view, truncated dorsally by the straight hinge which is about nine-tenths of maximum length. Cardinal angles well defined though obtuse. Plenate end higher than the other, broadly convex with the greatest extension at about the midheight. Antiplenate terminus is recessive in lower part and curves smoothly into the moderately convex ventral margin. Maximum height is three-fifths of length, and lies about two-fifths of distance from plenate margin. Hingement appears simple; overlap not observed.

Surface of valve moderately convex. In terminal view, valve is semiovate in outline, fullest ventrally, most convex about one-third above ventral margin. In ventral view, valve likewise is semiovate in outline, most convex about at midlength. A single, subvertical sulcus, lying just adplenate to midlength, is deep and well defined in upper half of valve; it has an obscure, shallow, adplenately bent ventral extension. Surface slightly swollen on adplenate side of deep part of sulcus, forming an obscure suggestion of a median lobe.

Except for the smooth-floored sulcus, surface of valve is completely covered with numerous small, closely crowded papillae of variable size. In the ventral part of the one specimen observed, the papillae extend into thin spinules; two larger papillae, which may have borne stronger spines, lie near the ventral margin at positions one-fifth and three-fourths the distance, respectively, from plenate end.

Length 1.03 mm., height 0.64 mm., maximum convexity 0.27 mm.

Relationships.—Although *Ctenobolbina ci-*

liata (Emmons), the Ordovician genotype of *Ctenobolbina*, is strongly bisulcate, a considerable number of unisulcate species are currently retained in the genus. In these the sulcus commonly is long, reaching well toward the ventral margin of the valve; in some there is a narrow, incomplete, nonstriate, submarginal frill; the surface tends to be ornamented by pits or by papillae. The new *C. windomensis*, with its strongly papillose surface and the weak ventral extension of its sulcus, is tentatively referred to *Ctenobolbina* as another unisulcate species, although the sulcus proper is relatively short.

Occurrence.—The one specimen was found in the Windom member of the Moscow formation at Bowen Brook, near Attica, New York.

CTENOBOLBINA LONGISULCATA Swartz and Oriel, n. sp.
Plate 79, figure 7

Carapace subovate in lateral view, truncated dorsally by the long, straight hinge. Adplenate cardinal angle obtuse; other angle not observed. Plenate end broadly rounded, with its greatest extension about at midheight. Antiplenate end broken in the single observed specimen.

Surface of valve strongly convex. In terminal view valve outline is subsemielliptical, the greatest convexity submedian. In dorsal view maximum convexity is attained near median sulcus by flattened summit of antiplenate lobe; from the summit of the lower, adplenate lobe, the surface drops toward the plenate margin with a moderate slope, then flattens to form a narrow submarginal border. A wide, deep, well defined sulcus, curving somewhat adplenately, extends from the dorsal margin to within one-fifth distance from the ventral margin.

Except for the smooth floor of the sulcus, surface of valve is covered with numerous round, closely spaced, irregularly arranged pustules, each with a minute pit at its summit; the pustules are strongest and relatively uniform in height over summit of adplenate lobe; somewhat lower on summit of antiplenate lobe; almost obsolete, except for the pits, near the margins of the valve. These pustules may be the bases of spines whose summits have been abraded; but if so it is surprising that the pustules are stronger on the summits of the lobes.

Length about 1.3 mm., height 0.9 mm., maximum convexity 0.5 mm.

Relationships.—*Ctenobolbina longisulcata* is unisulcate like *C. windomensis*, but the sulcus is decidedly longer, and the pustules are less numerous, less variable in size, and pitted at their summits.

Occurrence.—The one known, incomplete specimen was found in the Windom beds at Bowen Brook, near Attica, New York.

Genus CTENOLOCULINA Bassler, 1941

The genus *Ctenoloculina* was named by Bassler (1941), using the Middle Devonian *Tetradella cicatricosa* Warthin (1934) as the genotype. *Cicatricosa* strongly suggests the Ordovician, unquestioned members of *Tetradella* Ulrich in presence of four long, subvertical lobes and three intervening furrows. Warthin, however, remarked that "the juvenile stages of this beautiful species are not like those of *Tetradella* . . . . Young carapaces about 0.3 mm. in length are spinose rather than ridged, . . . " (Warthin, 1934). Furthermore, the expanded, dimorphic border of the female valve, with its porthole-like external openings, is closely similar to that of the Middle Devonian *Hollina cavimarginata* (Ulrich, 1900) and *Tetrasacculus minimus* (Ulrich, 1891). *Hollina cavimarginata* has a spinose-lobate rather than ridged surface. Early Devonian and Silurian ostracodes clearly linking *cicatricosa* with the Ordovician *Tetradella* have not been recognized, so that present knowledge suggests that the affinities of *cicatricosa* and of *Ctenoloculina* as a whole should probably be sought in Devonian Hollinidae rather than in Ordovician tetradellids. On this basis, *Ctenoloculina* is here listed provisionally under the Hollinidae, pending future discoveries.

The expanded border of *Hollina cavimarginata* was considered to be a specific rather than dimorphic structure by Ulrich (1900). It is reasonably clear, however, that *cavimarginata* must be the female dimorph of *Hollina armata* (Ulrich, 1900), with dimorphic structures closely comparable to those of *Ctenoloculina cicatricosa* (Warthin) and *Ctenoloculina acanthophora* Swartz and Oriel, n. sp. *Cavimarginata* and *armata* occur

in association in the bryozoan bed of the Jeffersonville limestone at the Falls of the Ohio River, and the surface ornament is closely similar except for the expanded border of *cavimarginata* with its portholed chambers.

CTENOLOCULINA ACANTHOPHORA
Swartz and Oriel, n. sp.
Plate 79, figures 8–14

Possibly *Tetradella cicatricosa* CORYELL and MALKIN, 1936, Am. Mus. Novitates, No. 891, p. 3, fig. 9; not *Tetradella cicatricosa* WARTHIN, 1934, Contrib. Mus. Paleo., Univ. Mich., IV, No. 12, p. 209, pl. I, figs. 4–6.

Carapace subelliptical in lateral view, truncated dorsally by the long, straight hinge which is almost equal to maximum length. Cardinal angles prominent, the adplenate angle about 115 degrees, the other about 90 to 100 degrees. Ends subequal in height; plenate end extended slightly beyond hinge; ventral margin moderately convex, fullest adplenately to midlength. Hinge surface imperfectly preserved in studied specimens; in one valve there is a suggestion of very fine denticulation.

Surface crossed by three broad and fairly deep subvertical sulci which extend from dorsal margin almost to the ventral margin; median sulcus sigmoidal in shape, deepest dorsally. Lobes, which vary in size and shape, have flattened summits with low but sharply elevated, very narrow rims. Antiplenate lobe is much the broadest, its inner margin about straight; next lobe varies in width, the side adjacent to the median sulcus being strongly sigmoidal; medioadplenate lobe nearly straight and about constant in width; adplenate lobe is suboval, much shorter than the others.

Surfaces enclosed by rims of lobes are reticulate and tend to have spinules formed by elevation of the junctions of the reticulations. On the observed material, the reticulation is weak on the median lobes, the spinules strong; on the terminal lobes the spinules are weaker. Median lobes are extended ventrally and there continue into flattened, fairly long spines that curve antiplenately; the spines are retained on one fragment, and their bases are evident on other specimens. A weak angulation or narrow rim lies close to the ventral edge of the valve and bears numerous minute spinules; the rim weakens on the terminal margins, and evidence is lacking as to whether spinules are present there.

In the female dimorph, a distinct swelling extends along the plenate and ventral margins about to the antiplenate sulcus. This swelling contains six chambers that open on the outer surface near the free margins; in the one observed female example, these chambers also open into the inner cavity of the shell, but though the inner orifices are relatively regular, they have probably been opened by breakage since the chambers do not connect with the valve interior in related members of the genus.

Internally, only the larger external features are manifest; external sulci appear as similarly shaped lobes, and external lobes appear as depressions. Muscle scars not observed.

Length 1.14 mm., height excluding ventral spines is 0.68 mm.

Relationships.—Ctenoloculina acanthophora is closely related to *C. cicatricosa* (Warthin, 1934) of the Norway Point limestone of Michigan. In the latter form, the ventral ends of the two median lobes are said to project below the ventral margin in male valves, but the elongate ventral spines of *acanthophora* do not seem to be present. As figured by Warthin, each of the two median lobes bears a single row of pustules, and in female valves the adplenate lobe is smooth, whereas in *acanthophora* the surfaces of all these lobes are reticulate with spinules at the junctions. The specimens from the Hungry Hollow limestone of Ontario, figured as *cicatricosa* by Coryell and Malkin in 1936, may prove to belong in *C. acanthophora*, but the ornament of the lobes is poorly preserved, and the nature of the ventral ends of the median lobes of the male valve has not been determined.

Occurrence.—This species is represented by three valves and several fragments from the Windom beds at Bowen Brook, near Attica, New York.

Family KIRKBYIDAE Ulrich and Bassler
Genus AMPHISSITES Girty 1910
AMPHISSITES LACRIMOSUS Swartz
and Oriel, n. sp.
Plate 79, figure 15

Carapace subquadrate in lateral view,

dorsally truncated by straight hinge which is about seven-eighths of maximum length. Maximum height, slightly less than three-fourths of maximum length, lies about one-third distance from plenate margin. Cardinal angles sharp, subequal, about 115 degrees. Ends gently convex in outline, extending subequally beyond hinge; plenate end fullest below middle; antiplenate end most extended medially, somewhat recessive where it bends into the ventral margin; ventral margin gently convex.

Hinge and contact relationships not observed.

Surface of valve bordered along free edges by a narrow submarginal rim that extends from cardinal angle to cardinal angle, and rises above the furrow-like depression on its inner side; ventrally, the rim overhangs the contact edge. Area enclosed by rim is convex, coarsely reticulate, with a submedian pit that is vertically elongate and dorsally acuminate so that it resembles a tear-drop in outline. Antiplenately to the pit, the surface rises in a poorly defined lobe whose summit, at a point one-third of respective distances from antiplenate and dorsal margins, reaches a convexity equalling about half the height of the valve. The lobe is elongate vertically, its dorsal end rising steeply from the hinge. On the other side of the pit, the surface, at a point about one-quarter of distance from the plenate margin, rises to a low prominence and then descends to the neighboring margins.

In the holotype, and only known specimen, the coarse pits enclosed by the surface reticulation are so arranged that they tend to form rows imperfectly concentric about the kirkbyid pit; they are in addition roughly aligned in other varying directions. The floors of the pits are open, presumably due to breakage of the thinned parts of the shell wall. On one small area, adjacent to the adplenate cardinal angle, the surface is not reticulate or pitted.

The holotype specimen measures about length 0.88 mm., height 0.62 mm.

Relationships.—Amphissites lacrimosus somewhat resembles *A. subquadratus* (Ulrich), of the Jeffersonville limestone of Kentucky and the Traverse group of Michigan, in its general form, presence of a keel along the free margins, and general character of reticulation. The adplenate angle is, however, sharper, the curvature of the margins is more regular without marked ventral truncation, the kirkbyid pit is dorsally acuminate in shape rather than round, the lobe-like convexities of the surface are more strongly elevated, and the submarginal ridge lies closer to the terminal edges.

Family KLOEDENELLIDAE Ulrich and Bassler
Genus JONESINA Ulrich and Bassler 1908

JONESINA (?) SINISTRALIS
Swartz and Oriel, n. sp.
Plate 79, figures 16, 17

Left valve elongate-ovate in outline in lateral view; dorsal margin convex, due to umbo which rises above the straight hinge contact that extends about three-fourths of length of valve. The umbo is asymmetrical, and greatest height of valve, which is about two-thirds of length, is situated about two-fifths distance from posterior end. Anterior margin narrowly curved, rounding into dorsal as well as ventral margin. Ventral margin moderately convex. Posterior end higher than the anterior, subangulate at midheight; in interior view there is also a weak angulation between the posterior margin and the hinge. Contact edges of valve lie about in a plane, without a hinge tooth or notch.

Valve moderately convex; as seen in posterior view, the surface rises steeply from ventral margin to the point of maximum convexity, which is subangulate and lies about at midheight; umbo projects beyond hinge about one-seventh of height of valve. In ventral view, the valve is subsemiovate in outline, with greatest convexity about one-third from posterior end.

Median sulcus, lying about two-fifths distance from anterior end, is narrow dorsally, deepened near its ventral extremity where it bends anteriorly and has a shallow, posteriorly directed branch. Anterior sulcus shallow, short; this sulcus is poorly defined on anterior side, but the surface rises steeply from it to the median lobe. Close to post-dorsal angle, there is a small, rounded node; at midheight of valve there are two smaller and weaker nodes on the slope to the posterior margin; a fourth, even smaller node lies close to the posterior margin about one-fourth distance above ventral margin.

The holotype and only known valve measures length 0.65 mm., height 0.39 mm., maximum convexity 0.19 mm.

Relationships.—The single known left valve of *Jonesina (?) sinistralis* suggests the Kloedenellidae because of its elongate form, antero-dorsal sulci, and the long hinge visible in the internal view of the valve. The direction of overlap, originally used by Ulrich and Bassler to distinguish *Jonesina* from *Kloedenella*, has not been established in *sinistralis*.

Sinistralis is highly abnormal for both *Jonesina* and *Kloedenella* in the strong umbo of the left valve. Umbos or dorsal crests are low or wanting in species of *Jonesina* known to the writers; where present in *Kloedenella*, as in *Kloedenella gibberosa*, they tend to be restricted to the right valve and are lacking in the left.

Except for the sulci, the form of the valve of *sinistralis* is suggestive of *Spinovina* (see Plate 79, figs. 25, 26), and membership in the Kloedenellidae may need further confirmation.

Occurrence.—Rare in Windom beds at Bowen Brook, near Attica, New York.

Family QUASILLITIDAE Coryell and Malkin
Genus QUASILLITES Coryell and Malkin, 1936

The genus *Quasillites* was described by Coryell and Malkin (1936) in the following words:

> Carapace subovate to rhomboidal; hinge line straight. Ventral margin straight to gently convex. Right valve larger than left, with a grooved contact to receive the left valve. Surface of valves is marked by fine longitudinal ridges and grooves, bifurcating along a median line, and diverging slightly anteriorly. A less ornamented median spot is usually discernible. Posterior convexity is generally elevated into a ridge-like surface at the crest of the steep posterior slope. A spine projects forward from the anterior ventral region, at the crest of the anterior slope.

In studying the species of *Quasillites* in the Windom fauna, the writers soon discovered that the opposing valves tend to differ considerably in shape, with the right-plenate valve more ovate than the other and more convex dorsally. This is strikingly true in *Q. lobatus*, as can be seen in the accompanying illustrations. The junior author was subsequently able to examine the genoholotype of *Q. obliquus* at the American Museum of Natural History, and found in that species likewise that the dorsal margin of the right-plenate valve is distinctly convex, even though the left-plenate valve has the obliquely subrhomboidal form from which the specific name evidently was derived.

Since the right-plenate valve of *Quasillites obliquus* has this dorsal convexity and subovate outline, doubt is raised about the validity of *Spinovina* Coryell and Malkin (1936). *Spinovina* resembles *Quasillites* in form of ornament and presence of a ventro-antiplenate spine, but was "differentiated from *Quasillites*, chiefly because of the ovate outline of the carapace and the deeply channelled hinge of *Spinovina*." A single right-plenate valve was figured by Coryell and Malkin for *Spinovina*, and the problem raised by valve differences was not considered.

One right-plenate valve is figured and described in the present paper under the name, *Spinovina sp.*, pending a restudy of the valve relations in the type of that genus.

In view of the confirmation of convexity of the dorsal margin in the right-plenate valve of *Quasillites obliquus*, as well as discovery of this condition in *Q. lobatus* and other species of the Windom collections, the following, modified generic definition is suggested for *Quasillites*:

Shell subovate to rhomboidal in lateral outline; valves somewhat unequal in size and proportions; left-plenate valve has a grooved contact to receive edge of the other valve; the right-plenate valve is comparatively more elongate than left-plenate valve, and has a more convex dorsal margin. Surface of valve is marked by fine, more or less longitudinal ridges and grooves, that fail over a smooth median spot. A ventro-antiplenate spine is persistently developed in known species.

In thinking of the plenation of the valves of *Quasillites*, attention must be given to the limits of the hinge. In left-plenate valves the direction of swing and the projection of the plenate end beyond the hinge is generally apparent; in right-plenate valves, however, the increased convexity of the dorsal margin obscures the limits of the hinge, and the

plenate margin tends to be more narrowly rounded than the other; in this valve it is the greater extension beyond the hinge that distinguishes the plenate end.

The smooth submedian spot of *Quasillites* plausibly represents the locus of adductor attachment, although evidence of muscle scars has not been observed on the interior surface. The smooth spot lies distinctly closer to the plenate end than to the other, and on the supposition that it represents the position of the adductor, gives strong evidence that the plenate end of the shell is anterior and not posterior as considered by Coryell and Malkin. The importance for orientation of the adductor location was given early emphasis by Bonnema (1932). The writers believe that orientation of members of *Quasillites* with the plenate end at the front can be accepted without much question, even though this reverses previous usage.

QUASILLITES LOBATUS Swartz and Oriel, n. sp.
Plate 80, figures 1–8, 18

Carapace subovate to subrhomboidal in lateral view. Dorsal margin slightly to moderately convex in right-plenate valve, in which the ventral margin is straight to a trifle concave; in left-plenate valve the dorsal margin tends to be straighter, the ventral margin more convex. Adplenate cardinal bend recessive, rounded; in right-plenate valve, antiplenate cardinal bend is somewhat fuller than the other and it is still more prominent in the left-plenate valve.

Hinge and contact relationships not fully shown in the material at hand.

Valve strongly convex in terminal view; surface rises steeply from dorsum to the broadly convex summit, and descends more steeply to the ventral margin; maximum convexity is submedian. In ventral view, ter-

EXPLANATION OF PLATE 81

All illustrations approximately ×35 unless otherwise indicated.

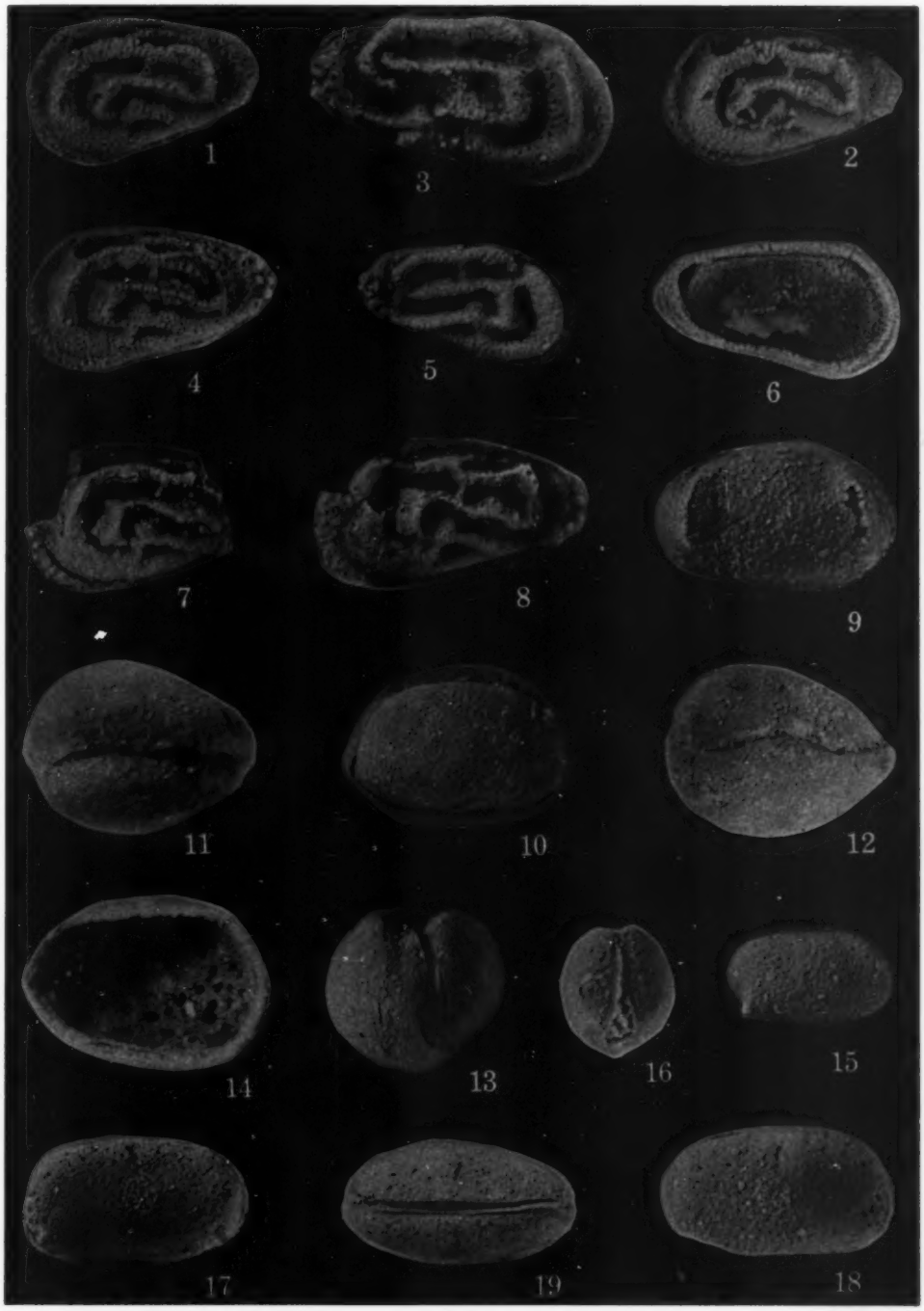
FIGS. *1–8—Euglyphella numismoides* Swartz and Oriel, n. sp. *1*, Lateral view of holotype left-plenate valve. *2*, Another left-plenate valve showing more convex dorsal margin. *3*, A right-plenate valve, ×45 ,showing pits on ridge slopes; the pits, found on two right-plenate valves, may prove to be pores of the valve wall, opened by weathering of the external surface. *4*, A left-plenate valve showing small nodes on the flanks of part of the upper limb of the outer furrow, and scalloping elsewhere along the furrows, *5*, Right-plenate valve showing gap above dorso-adplenate cross-bar and the dollar-sign appearance of the ornament. *6*, Interior view of a left-plenate valve; flanges extend beyond the actual contact edges along the terminal margins. *7*, Incomplete left-plenate valve showing undulations of surface of adplenate marginal flange; no other specimen shows this. *8*, Left-plenate valve ×45, showing spines just above dorso-antiplenate junction of the ridges. The figured specimens are from Windom beds, Bowen Brook, N. Y. (p. 562)

9—Condracypris subovalis Swartz and Oriel, n. sp. Lateral view of holotype right-plenate valve; summit of adplenate ridge is broken. Windom beds, Bowen Brook, N.Y. (p. 565)

10–14—Tubulibairdia windomensis Swartz and Oriel, n. sp. *10–13*, Views of holotype carapace. *10*, Right valve view showing inequality of valves and surface pitting. *11*, Dorsal view showing the larger left valve overlapping the smaller valve. *12*, Ventral view showing slight lip-like, ventro-median extension of left valve. *13*, Posterior view showing lip-like projection of dorsal part of posterior margin of left valve. *14*, Interior view of a left valve showing the dorsal umbonation and the internally-opening tubules. Windom beds, Bowen Brook, N. Y. (p. 563)

15—Lucasella cf. *cavanifera* Stewart and Hendrix. Lateral view of right-plenate valve showing ventro-antiplenate spine but no "antero-dorsal" spine. Windom beds, Bowen Brook, N. Y. (p. 564)

16–19—Lucasella sulcella Swartz and Oriel, n. sp. Views of holotype internal mold of a carapace. *16*, Antiplenate terminal view showing that left-plenate valve (on left) overlapped the other valve. *17*, *18*, Right-plenate and left-plenate views showing impressions, in each case, of muscle scars, of internal vertical ridge above muscle scar, and in *17*, of ventro-antiplenate spine. In *18*, the outline is somewhat imperfect in the ventro-adplenate region. *19*, Dorsal view showing impression of thickened hinge margin of valves. Windom beds, White Creek near East Bethany, N. Y. (p. 564)



Swartz and Oriel, Windom Ostracoda

minal slopes form angles of about 60 degrees to plane of commissure; intervening summit of valve rises to a gentle medio-adplenate swelling; the surface is somewhat hollowed adplenately to the median swelling.

As the valve is viewed laterally, the medio-adplenate swelling is subcircular in outline. A low, rounded ridge lies at the summit of the rise from the plenate margin, and is strongest dorsally. At the summit of the slope from the antiplenate margin, there is a strong ventro-antiplenate spine, and a low, dorso-antiplenate nodose swelling also tends to be present. There is in the right-plenate valve a very narrow, flattened rim along the ventral margin that widens as it continues along the ventral part of the plenate margin, then narrows above a sharp cusp which lies about at midheight.

Between the smooth, medio-adplenate swelling and the summits of the slopes from the terminal margins, the surface of the valve is marked by fine, irregularly bifurcating ridges, the furrows between them divided into small, somewhat elongate pits by numerous cross-bars; some of the apparent variation in development of the pitting seems to result from differences in preservation of the summits of the ridges. In the antiplenate ornamented areas, the ridges are arranged roughly lengthwise the valve; in the smaller, adplenate region, the upper ridges tend to be oblique, more or less paralleling the dorsal part of the plenate margin, whereas the more ventral ridges may be longitudinal in disposition.

The large holotype valve measures length 1.27 mm., height 0.61 mm., maximum convexity 0.34 mm.

Relationships.—The material here included in *Quasillites lobatus* is subject to some variation in the convexity of the dorsal margin of the right-plenate valve, and to modifications in the detail of ornament, as well as to differences in outline of the opposing valves.

In the holotype right-plenate valve, as well as in the two figured left-plenate valves, the ridge ornament is comparatively coarse and the pitting of the intervening furrows relatively conspicuous. In two other large right-plenate valves the surface ridges are somewhat narrower and more closely spaced and the pitting is not well shown in the photographs, partly at least because the summits of the well-preserved ridges rise well above the summits of the cross-bars of the intervening furrows. With larger collections it may prove desirable to use the valves shown in figures 4 and 5 for erection of a distinct species; but this does not seem feasible at this time because of uncertainties about the role of preservation in causing the observed differences in ornament.

Associated with the large, reasonably well characterized specimens of *Q. lobatus* are various smaller valves that are tentatively, at least, regarded as immature examples of the species. The specimens illustrated in figures 7 and 8, Plate 80, agree reasonably well with the holotype valve in extent and coarseness of the ornament, prominence of the medio-adplenate smooth spot, characters of the ventro-antiplenate spine and the node dorsal to it, and presence of the low adplenate ridge. There is more question about the valve shown in figure 18 of the same plate, due to the narrowness and differing distribution of the surface ridges; the ridges of this specimen are, however, comparable to those of the valves shown in figures 4 and 5.

In *Quasillites lobatus*, the ridge ornament is restricted to smaller areas of the surface than is true of either *Q. obliquus* Coryell and Malkin (1936) or *Q. fordei* Coryell and Malkin (1936); furthermore, the ridges tend to be coarser and the pits of the intervening furrows shorter and more numerous.

As compared to *Q. ornatus* Swartz and Oriel, n. sp., *Q. lobatus* tends to be larger, the ridge ornament is coarser and covers less of the surface, the ridges of the antiplenate half do not take on a whorl-like arrangement, and there is a distinct dorso-antiplenate, node-like swelling.

Occurrence.—Common in the Windom beds along Bowen Brook, near Attica, New York.

QUASILLITES sp.
Plate 80, figure 9

Carapace subovate to subrhombic in lateral view. Dorsal margin almost straight. Cardinal angles rounded. Plenate end broadly rounded, fullest in lower part. Antiplenate end fullest one-third of height below

dorsal margin, recessive in lower part. Ventral margin broadly convex. Hinge and contact relationships not evident in observed specimen.

Valve strongly convex; surface most convex medially in terminal view. In ventral view, summit of valve surface is gently convex, descending rapidly to the terminal margins; maximum convexity is slightly antiplenate to midlength. Only a shallow, poorly defined, dorso-adplenate depression disrupts the regular convexity of summit of valve surface. There is a strong, ventro-antiplenate spine.

Surface ornamentation restricted to two small areas. In the smaller area within the dorso-adplenate depression, there are a number of fine ridges roughly paralleling the adplenate cardinal bend. A somewhat larger area of ornament in antiplenate half of valve consists of two series of fine, subparallel ridges, the furrows between them divided into small, elongate pits by numerous cross-bars; the lower series covers a greater area and roughly parallels the dorsal margin; the upper series diverges slightly from the lower series in the antiplenate direction, and is diagonal to the dorsal margin.

The single observed valve measures 0.92 mm. in length, height 0.54 mm., maximum convexity 0.27 mm.

Relationships.—The left-plenate valve described in the foregoing paragraphs is suggestive of *Q. lobatus*, and perhaps should be considered an immature example of that species. It differs, however, from the supposed youthful valves of *lobatus* illustrated in figures 7 and 8, because of the greatly reduced area of the surface ornament.

Occurrence.—One left-plenate valve from the Windom beds, Bowen Brook, near Attica, New York.

QUASILLITES ORNATUS
Swartz and Oriel, n. sp.
Plate 80, figures 11–17

Carapace subrhomboidal to subovate in lateral view. Dorsal margin gently convex in right-plenate valve, generally straighter in the other valve. Adplenate cardinal bend broadly rounded; antiplenate cardinal bend more prominent, and more sharply curved at least in the left-plenate valve. Plenate margin broadly curved, somewhat more prominent below than above, projecting beyond hinge about one-fifth to one-sixth of length of carapace. Antiplenate margin fullest above, recessive below. Ventral margin nearly straight.

Hinge and contact relationships not determined.

Valve strongly convex, the surface, in terminal view, rising steeply from the dorsal and ventral margins to the rounded summit, which is highest medially. In ventral view, the summit of the valve is flattened for almost three-fourths of the valve length, and reaches its greatest convexity about one-fourth distance from antiplenate end. At the plenate end, the surface rises steeply from inner margin of the flattened rim; the rise from the antiplenate margin is not quite so steep.

In lateral view, there is a small, barely elevated, submedian smooth spot. Surrounding parts of the elevated surface of the valve are ornamented by fine ridges whose intervening furrows are divided into numerous pits by small cross-bars. In the adplenate part of the valve, the ridges are roughly concentric with the adjacent parts of the margin of the valve; in the antiplenate region the ridges take on a whorl-like arrangement. Dorso-adplenately to the median spot, the surface is gently depressed. A distinct spine lies close to the ventro-antiplenate bend of the margin. A very narrow rim extends along the ventral margin of the valve, broadens as it continues along the ventral half of the plenate end, then narrows abruptly above a cusp which lies about at midheight.

The holotype left-plenate valve measures length 0.92 mm., height 0.54 mm., maximum convexity 0.27 mm. A relatively more elongate left-plenate valve measures length 0.89 mm., height 0.50 mm., maximum convexity 0.24 mm.

Relationships.—As compared to *Quasillites lobatus*, *Q. ornatus* is a smaller species in which the ornament covers a greater part of the valve surface, the ridges of the antiplenate half take on a whorl-like arrangement, the median smooth spot is smaller and less swollen, and the dorso-antiplenate node of *lobatus* is scarcely, if at all represented.

The whorl-like arrangement of the ridges

in the antiplenate half of the valve is reminiscent of *Q. fordei* Coryell and Malkin (1936) of the Hungry Hollow limestone of Ontario; but in that species the median spot is smaller, and the ridges as illustrated are finer, with fewer cross-bars and pits in the intervening furrows. As illustrated, *fordei* lacks the cusp of the rim of the plenate margin; indeed, it is not clear whether any rim occurs in that species.

Occurrence.—Common in the Windom beds at Bowen Brook, near Attica, New York.

QUASILLITES SUBOBLIQUUS
Swartz and Oriel, n. sp.
Plate 80, figure 10

Carapace subrhomboidal to subelliptical in lateral view. Dorsal margin of left-plenate valve is straight or nearly so for five-eighths of maximum length. Adplenate cardinal bend rounded, obtuse; in left-plenate valve antiplenate cardinal angle is prominent, about a right angle. Plenate margin gently curved above, more fully rounded in lower part with greatest extension beyond hinge at about one-third distance above ventral margin. Antiplenate margin fullest dorsally, recessive below. Ventral margin gently convex. Maximum height is three-fifths of length and lies about one-third distance from plenate end. Hinge and contact relationships not evident in the one specimen at hand.

Valve surface strongly convex; in terminal view, outline is subsemielliptical with maximum convexity about at midheight. Outline in ventral view is subtrapezoidal, the terminal slopes steep; adplenate slope is gently concave, antiplenate slope about straight; submedian unornamented spot forms a poorly defined swelling; surface rises to point of maximum convexity about one-fourth distance from antiplenate margin. Dorsally, there is a poorly defined, shallow depression between the submedian smooth spot and the crest of the adplenate slope. A prominent spine lies near the ventro-antiplenate margin, but is incomplete in the single specimen studied.

Summit of valve, except for the median spot, is ornamented by fine ridges; in adplenate part of valve, the ridges are roughly concentric with the plenate margin; in antiplenate half, the ridges extend lengthwise the valve, and diverge slightly antiplenately. In the single specimen, the floors of the furrows between the surface ridges are not pitted; this may be due to imperfect preservation of the detail on the pyritic replacement.

The one observed specimen measures length 1.13 mm., height 0.68 mm., maximum convexity of valve 0.31 mm.

Relationships.—Quasillites subobliquus is very close to *Q. obliquus* Coryell and Malkin (1936) of the Hungry Hollow beds of Ontario. On the basis of the single known example, it differs chiefly in the more ventral position of the spine, as well as in the lesser obliquity of the outline, and the greater proportional height. Judging from the other Windom species of *Quasillites*, the position of the spine is an essentially stable specific character, whereas proportionate height is more variable. Information is needed about the constancy of position of the spine in *Q. obliquus* of the Hungry Hollow beds in order to place the differentiation of the species on a firmer basis.

Q. subobliquus likewise suggests the smaller *Q. ornatus*, but the ridges of the antiplenate half of the valve do not have the whorl-like arrangement found in the latter form.

Occurrence.—Rare in the Windom beds along Bowen Brook, New York.

QUASILLITES BINODOSUS
Swartz and Oriel, n. sp.
Plate 79, figures 18–21

Carapace small, subovate to subquadrate in lateral view. Dorsal margin straight to barely convex, hinge about three-fourths of maximum length. Adplenate cardinal bend broadly rounded; antiplenate bend more prominent, more narrowly rounded. Plenate end broadly, rather regularly rounded, projecting beyond hinge for about one-sixth to one-seventh of length of valve. Antiplenate end lower than other, its curvature less convex; this end commonly is most prominent in its upper portion, but in one valve is most extended in its lower part. Ventral margin gently convex.

Hinge and contact relations not determined.

Valve in terminal view moderately convex,

the surface rising steeply from the ventral and dorsal margins to the gently convex summit which is highest medially. In ventral view, summit of valve is nearly flat for most of length; at plenate end, surface drops almost vertically to inner margin of the terminal flange; at antiplenate end the drop is not quite so steep.

As the valve is viewed laterally, there is a small, round, subcentral smooth spot. A small spine occurs at the ventral part of the summit of the antiplenate slope; a blunter spine or node with rounded apex rises from the dorsal part of this summit. Summit of the adplenate slope is rounded, and in the dorsal part tends to be thrown into slight relief by a very shallow depression on its inner side.

General summit of valve, except for the smooth submedian spot, is ornamented by fine, closely spaced ridges; numerous relatively strong cross-bars divide the intervening furrows into pits. In the adplenate half, the ridges are roughly concentric with the adjacent parts of the valve margins; in the antiplenate half, the ridges tend to be more nearly longitudinal to the valve; the ridges of the upper and lower parts of this half may diverge antiplenately or may curve to form a whorl. Flattened rim of plenate end tends to be relatively broad and lacks a cusp at midheight of valve; the rim is very narrow along the ventral margin.

The holotype valve measures length 0.62 mm., height 0.35 mm., maximum convexity 0.16 mm.

Relationships.—*Quasillites binodosus* is a small form in which the distribution of the surface ridges and furrows is suggestive of *Q. ornatus; binodosus* is, however, distinguished by its comparatively subquadrate outline, and the presence of the well-marked dorso-antiplenate node. The cross-bars and hence the pitting of the surface furrows are relatively prominent.

Because of the small size, it might be suspected that *binodosus* represents immature individuals of *Quasillites ornatus;* however, no transitional molt stages have been discovered.

Occurrence.—Windom beds at Bowen Brook, near Attica, New York.

Genus SPINOVINA Coryell and Malkin 1936

SPINOVINA sp.

Plate 79, figures 25, 26

Carapace strongly subovate in lateral view. Dorsal margin broadly convex; dorsum channelled along hinge so that valve is umbonate. Ends decidedly unequal in height; blunt terminal margin is broadly rounded; the other terminal margin is more narrowly curved, but extends much farther beyond limits of hinge. Ventral margin broadly convex. Maximum height is four-sevenths of length of valve, and lies one-third distance from blunt end. Hinge detail and contact relationships not wholly clear in the one valve studied, but hinge apparently extends between points that are respectively about one-sixth and five-eighths of distance from blunt end of valve; the narrow end of valve thus projects almost two and a half times as far beyond the limits of the hinge as does the higher end. As the valve is viewed from the interior, a narrow flange projects beyond the contact edge at the narrow end.

Valve strongly convex. In terminal view surface rises steeply from ventral margin to broadly convex summit, descends at moderate slope to dorsal umbo and recedes to the hinge; maximum convexity is about at mid-height. In ventral view, summit of valve is gently sinuate with a slight concavity in the half adjacent to the narrow end of valve; summit descends to terminal margins in fairly steep slopes. In ventral part of blunt end of valve is a low node that may be the base of a spine.

Surface rough, apparently due to poor preservation. In the ventral part of the valve surface, near the narrow end, there is a weak suggestion of spinovinid ridges.

The described valve measures length 1.05 mm., height 0.59 mm., maximum convexity 0.30 mm.

Relationships.—The single valve that is here described, is much more unequal-ended than is *Spinovina distributa* Coryell and Malkin (1936) of the Hungry Hollow limestone of Ontario, and the relative height is greater. Because of the poor preservation of surface detail, the authors have refrained

from describing the specimen as a new species.

The "plenate" terminology is not employed in the accompanying description since the height of the one end makes it appear plenate, whereas the narrower end actually extends much farther beyond the hinge, and therefore appears more properly to be the plenate end.

Occurrence.—One valve from the Windom beds at Bowen Brook, near Attica, New York.

Genus JENNINGSINA Coryell and Malkin, 1936

JENNINGSINA DIVARICATA Swartz and Oriel, n. sp.

Plate 79, figure 24

Shell subreniform in lateral view; dorsal margin convex, highest about two-fifths distance from plenate end; antiplenate to the high point, the dorsal margin is truncate and this may represent the locus of the hinge. Ends subequally rounded. Ventral margin gently concave.

General surface of valve gently convex, dropping steeply to ventral and antiplenate margins, more gently to the others; there is a narrow, ventro-adplenate, submarginal flange or border. In terminal view, greatest convexity is slightly above middle; in ventral view, greatest convexity is just adplenate to midlength.

Surface is marked by a deep, round, subcentral pit. Surrounding areas bear narrow ridges connected by cross-bars that enclose pits elongated parallel to the ridges. Ventrally the ridges are nearly parallel to ventral margin of valve; a more dorsal series diverges antiplenately from the lower group.

Length 0.63 mm., height 0.34 mm., convexity of valve 0.14 mm.

Relationships.—Jenningsina divaricata is very close to *J. catenulata* (Van Pelt, 1933) of the Bell shale of Michigan, but has been distinguished because of its more convex dorsal margin, and the lesser divergence of the upper ridges from the lower ones.

Occurrence.—A single valve from the Windom beds at Murder Creek, at Darien, New York.

Family THLIPSURIDAE Ulrich

Genus THRALLELLA Stewart and Hendrix, 1945

THRALLELLA CRISTATA Swartz and Oriel, n. sp.

Plate 79, figures 22, 23

Carapace subreniform to subovate in outline. Dorsal margin broadly convex, the curvature increasing adplenately. Ventral margin slightly concave to straight. Plenate margin broadly convex, with greatest extension one-third above ventral margin. Antiplenate end more narrowly and asymmetrically curved. Maximum height is five-ninths of length and lies one-third of distance from plenate end.

Valve in terminal view moderately convex, the surface rising more steeply from dorsal margin than from ventral; convexity greatest slightly above midheight.

In dorsal view valve is subsemiovate; general surface gently convex, reaching a maximum convexity one-third distance from plenate end; slope to antiplenate end is moderately steep; that to plenate end is steep, concave, and has at its summit a distinctly elevated angulation.

Adjacent to the adplenate angulation, the surface bears in the single observed specimen 36 fairly deep, irregularly spaced pits, imperfectly aligned in vertical rows. Four or five pits occur near antiplenate end. Internally, a rounded, roughened and partly broken spot about at center of valve may represent locus of the adductor scar; there is a low subvertical internal ridge on the adplenate side of the spot.

Length of holotype 0.95 mm., height 0.50 mm., convexity of valve 0.32 mm.

Relationships.—As compared to *Thrallella mimica* Stewart and Hendrix (1945) of the Olentangy shale of Ohio, *T. cristata* is larger, relatively less elongate, has more numerous pits in the antiplenate part of the valve, and possesses several antiplenate pits whereas none occur in *mimica.*

The genus *Thrallella* is reminiscent of *Stibus* Swartz and Swain (1941); but in the latter genus the carapace tends to be somewhat more subrhomboidal in outline, a

groove parallels part of the plenate margin, and a pair of spines projects from the summit of the antiplenate slope of each valve.

Occurrence.—A single valve from the Windom beds along Bowen Brook, near Attica, New York.

Family ROPOLONELLIDAE Coryell and Malkin
Genus EUGLYPHELLA Warthin, 1934
EUGLYPHELLA NUMISMOIDES Swartz and Oriel, n. sp.
Plate 81, figures 1–8

Carapace subtriangular to subovate in lateral view. Left-plenate valve overlaps the smaller right-plenate valve; greatest height of larger valve lies about one-fourth distance from plenate end and is about two-thirds of length; maximum height of smaller valve is not quite half of its length. Dorsal margin of each valve slightly convex. Plenate end broadly rounded, about twice as high as the narrowly curved opposite end; plenate margin of smaller valve is much extended ventrally. Ventral margin, decidedly oblique to hinge, is nearly straight for a distance of about two-thirds of maximum length.

Hinge slightly less than two-thirds of maximum length; in left-plenate valve a narrow groove extends longitudinally along the lower part of the contact surface of the hinge, and appears to have received the narrow contact edge of smaller valve.

Surface of valve ornamented by a pair of C-shaped ridges which curve concentrically to each other and to the dorsal, the plenate, and part of the ventral margins of the valve. The upper limbs of the curved ridges are joined antiplenately; the lower limb of the outer ridge dies out halfway from plenate end of valve; the lower limb of the inner ridge is oblique to the ventral margin and dies out about two-thirds distance from plenate end of valve. The furrow between the two ridges is interrupted by two aligned cross-bars; one is about at midlength of upper limb of furrow; the other lies in lower limb of furrow, about two-fifths distance from plenate end of valve, so that the tip of the furrow forms a triangular pit. An extension of the lower bar accentuates the angulation of the down-bent end of the furrow enclosed by the inner C-ridge. In the right-plenate valve an additional bar crosses the upper limb of the outer furrow at its dorso-adplenate curve; this bar is incomplete in the left-plenate valve.

In the left-plenate valve, the summits of the ridges tend to be sharply carinate; from the carinae the surface slopes gently at first, then steepens sharply as it drops to the floor of its adjacent furrow; in one specimen, the margins of this overdeepened, median part of the furrow are locally somewhat scalloped, and there are several small nodes on each flank in the antiplenate end of the upper limb of the furrow between the two ridges. At the antiplenate end of the upper limb of the outer ridge, the carinate summit of the ridge tends to be produced as a wedge-shaped, spinose process; the dorsal slope of the outer ridge bears two elongate depressions, bounded adplenately by curved crests branching from the carinate summit, with the median crest elongated parallel to the dorsal margin.

In right-plenate valve the ridges tend to be less carinate; the spinose process at the antiplenate end of the upper limb of the outer ridge is weak or absent, and the depressions on the dorsal slope are obsolete. A gap interrupts the outer ridge just above the dorso-adplenate cross-bar, and the upper limb of the outer ridge combines with the inner ridge, simulating a dollar sign.

In the left-plenate valve a flange extends along the dorsal and terminal margins, but ventrally is absent or very nearly so. The flange is broadest antiplenately, where it is swollen and bears about six papillae. In the right-plenate valve, the flange is obsolete along the dorsal margin; its terminal parts are narrower than in the other valve. Terminally, the outer part of the flange projects beyond the contact edges.

The holotype valve measures: length 0.93 mm., height 0.55 mm., maximum convexity 0.30 mm.

Relationships.—*Euglyphella numismoides* is closely related to *E. sigmoidalis* (*Strepula sigmoidalis* Jones, 1890 = *Strepula planataris*, Jones, 1890 of the Wanakah shale of New York). (See Warthin, 1945.) After examination of the holotype left-plenate valve of *sigmoidalis*, the junior author comments that there is no spinose process near the dorso-antiplenate end of the outer ridge;

there is no cross-bar at the midlength of the upper limb of the furrow between the two ridges; the furrow between the two ridges does not have a distinct medial deepening; the floors of the furrows are not completely free of matrix, but appear to have a single row of pits; the furrow enclosed by the inner ridge does not have a downbent inner end.

In a valve from the Hungry Hollow beds of Ontario, figured as *E. sigmoidalis* by Coryell and Malkin (1936), the floor of the furrow between the two ridges is marked by pits that are in part arranged in two rows.

Occurrence.—Abundant in the Windom beds at Bowen Brook, near Attica, New York; one additional specimen came from White Creek at East Bethany, and another was found at Little Beard Creek, near Leicester, New York.

Genus BUFINA Coryell and Malkin 1936
BUFINA sp.

Occurrence.—A single valve of a species of *Bufina* was found in the collections supplied by Dr. Eller, but unfortunately was broken before it could be photographed or described. Its presence is mentioned to record the appearance of the genus in the Windom faunule. The specimen came from Bowen Brook, near Attica, New York.

Family BAIRDIIDAE Sars
Genus TUBULIBAIRDIA Swartz
TUBULIBAIRDIA WINDOMENSIS Swartz and Oriel, n. sp.
Plate 81, figures 10–14

Carapace subovate in lateral view; inequivalved, with left valve larger than and projecting beyond the right along all the margins. Dorsal margin of left valve moderately convex, rounding into the terminal margins; ventral margin gently convex, decidedly longer than dorsal margin, so that both ends of shell are most extended ventrally; anterior or plenate margin fullest and sharply rounded below, gently rounded above; posterior margin sharply angulated about one-third distance above ventral margin. Maximum height is two-thirds of length and lies one-third distance from anterior end. Smaller valve is subelliptical in lateral view, not as high but almost as long as the left valve. Actual hinge margin of valves is almost straight for two-thirds of length of carapace, the umbo of the left valve rising above it for almost one-sixth the maximum height of carapace; left valve overlaps right along free margins, with a distinctly projecting lip-like extension at about the middle of the ventral margin, and a less conspicuous expansion situated between the post-ventral angulation and the posterior end of the hinge.

Valves are strongly, subequally convex, the greatest thickness of the carapace being about at midheight.

In the holotype, a complete carapace, the surface is marked by minute, rather closely spaced pits. In two other specimens, which are separated left valves, coarse pores open on the inner surface; most of these pores likewise open on the outer surfaces of the two specimens and apparently have been enlarged by wear or corrosion of the outer layer of shell wall. These coarse pores are much less numerous than the fine external puncta of the holotype carapace. The coarse pores are absent in a small area near to and extending above the middle of the valve, and this place was probably the locus of the adductor attachment.

The dimensions of the holotype carapace are as follows: length 0.89 mm., height 0.62 mm., thickness 0.65 mm.; the smaller, right valve measures length 0.84 mm., height 0.53 mm.

Relationships.—Tubulibairdia windomensis differs from *T. tubulifera* Swartz (1936) in the anterior rather than posterior position of greatest height, and the somewhat less numerous, inwardly-opening tubules. Comparisons with *T. paucitubulis* Swartz and Swain (1941) are made difficult by the imperfection of the molds on which that species was based; the molds show clearly that *paucitubulis* has fewer tubules than *windomensis;* the molds do not satisfactorily preserve the valve outlines, although it does appear that the right valve is more nearly subquadrate than in *windomensis.*

Occurrence.—The one carapace and two left valves of *Tubulifera windomensis* come from the Windom beds at Bowen Brook, near Attica, New York.

Genus LUCASELLA Stewart, 1936
LUCASELLA cf. CAVANIFERA Stewart and Hendrix
Plate 81, figure 15

Lucasella cavanifera STEWART and HENDRIX, Jour. Paleontology, vol. 19, No. 2 (1945), p. 93, pl. 10, figs. 19, 20.

Carapace elongate-subelliptical in lateral view, the greatest height slightly more than half of length. Hinge margin nearly straight for about three-fifths of length. Plenate margin rounded, somewhat truncate above, more protuberant below. Rounding of antiplenate margin relatively regular, though slightly fuller above than below. Ventral margin slightly convex.

Valve moderately convex, the surface rising with a slope of about 45 degrees from the antiplenate margin to the gently convex summit; surface drops more abruptly to plenate margin, then flattens to form a very narrow rim.

A well defined spine lies close to the ventro-antiplenate margin. There is no trace of a dorso-antiplenate depression.

The figured specimen measures length 0.66 mm., height 0.35 mm., maximum convexity 0.15 mm.

Relationships.—The specimen here described agrees closely with *Lucasella cavanifera* Stewart and Hendrix in outline and in location of the ventro-antiplenate spine. On the other hand it lacks the dorso-median depression of *cavanifera*. Stewart and Hendrix state that *cavanifera* has a "small spine in anterodorsal position"; they do not mention the ventro-antiplenate ("anteroventral") spine shown in their illustrations of the species so that the writers are not sure whether the "anterodorsal" is an error for "anteroventral"; in the specimen here described at least, there is no dorso-antiplenate spine.

Comparison with modern ostracodes with respect to both outline and position of the adductor favors the view that the plenate end of the carapace is anterior in *Lucasella*, rather than posterior as it was considered by Stewart.

Occurrence.—Rare in Windom beds, Bowen Brook, near Attica, New York.

LUCASELLA SULCELLA Swartz and Oriel, n. sp.
Plate 81, figures 16–19

Internal mold of carapace elongate-subelliptical to subrhomboidal in lateral view; maximum height about five-ninths of length. Dorsal margin very gently convex; hinge two-thirds of maximum length, slightly channelled in antiplenate half. Cardinal angles rounded; adplenate angle more broadly rounded than the other. Plenate margin broadly and regularly rounded; antiplenate margin somewhat truncated above, most extended below where it bends rapidly to the ventral margin. Ventral margin slightly convex for a distance somewhat greater than length of hinge.

Left-plenate valve is barely larger than right-plenate, and overlaps latter along free margins. Hinge margin of each valve slightly thickened, leaving a shallow groove on internal mold.

Valves moderately convex, the carapace-outline in terminal view subovate, the greatest thickness just below midheight. In dorsal view, the carapace-outline is subovate, with greatest thickness just adplenate to midlength.

A small spine lies close to ventro-antiplenate margin of valve.

In the holotype internal mold, the impression of the muscle scar of each valve is a round, roughened spot, barely adplenate to center of valve. Above the scar impression is a narrow, subvertical, depressed line, representing a ridge on the valve interior and presumably a shallow depression on the external surface.

The holotype internal mold of a carapace measures length 0.82 mm., height 0.46 mm., maximum thickness 0.42 mm.

Relationships.—*Lucasella sulcella* has been named somewhat reluctantly from a single internal mold of a carapace. Judging from the specimen, however, the outline differs from that of *Lucasella cavanifera* Stewart and Hendrix in the distinct truncation and ventral protrusion of the antiplenate margin.

Occurrence.—One specimen from the Windom beds along White Creek, near East Bethany, New York.

Family CYPRIDAE Zenker
Genus CONDRACYPRIS Roth, 1929
CONDRACYPRIS SUBOVALIS Swartz and Oriel, n. sp.
Plate 81, figure 9

Carapace reniform to subovate in lateral view. Dorsal margin convex, highest about two-fifths distance from anterior end; maximum height about two-thirds of length. Ends rounded with the plenate or anterior end somewhat higher than the posterior. Ventral margin nearly straight for about three-fifths of length, with a gentle, median concavity. In the right valve, the hinge edge as observed in the interior view of the valve is narrow-crested and straight for about three-fifths of valve length, with its anterior end in the region of greatest height; whether this thin edge fits into a groove in the hinge surface of the opposite valve is not known. On interior of valve, an obscure, rounded, median spot may represent the adductor scar.

Valve moderately convex, the surface dropping very steeply to ventral margin and somewhat more gently to dorsal margin. About one-eighth distance from each extremity of the valve is a well elevated, subvertical ridge, the crest angulated, the slope toward the adjacent margin steep, slightly concave. The summit of the posterior ridge rises slightly above the point of greatest convexity of the general surface, which is a trifle posterior to midlength; the summit of the anterior ridge is about equal in elevation to the point of greatest convexity.

General surface smooth. Close to each terminal margin is a row of tiny spinules, their diameters about 0.015 to 0.02 mm. Anteriorly in the one observed specimen, there are 10 of these spinules, lying about at median third of height, and strongest at the midheight. Posteriorly there are 10, and may have been 15 such spinules, extending from slightly above mid-height to the ventro-antiplenate bend of the margin. The edge, exterior to the row of spinules, is narrowed, and may have been overlapped by the edge of the opposite valve.

Length of holotype valve 0.92 mm., height 0.53 mm., convexity 0.24 mm.

Relationships.—Condracypris subovalis is more elongate than *C. binoda* Roth (1929), and *C. simplex* Roth (1929); the ventro-terminal bends of the margin are rounded and not so prominent and angulated, so that the lateral outline is subovoid rather than subtrapezoidal; the two subvertical ridges are closer to the neighboring ends and their summits are more angular.

Evidence for placing *Condracypris* in the Cypridae rather than the Thlipsuridae is not now conclusive.

Occurrence.—The holotype, and only known specimen, comes from the Windom member of the Moscow formation, at Bowen Brook, near Attica, New York.

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A NEW LOWER ORDOVICIAN TRILOBITE

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ABSTRACT—*Ptyocephalus vigilans*, the genotype of a new Upper Canadian (Lower Ordovician) asaphid genus from the Pogonip of Nevada is described and illustrated. The genus is distinguished from all other asaphids by the rectangular outline of the strongly convex dorsal shield, the flattened terminations, the quadrangular outline of the cephalon, the pentagonal outline of the pygidium and the peculiar hypostome. Pygidia, believed to represent species of the genus, are known from the Upper Canadian of Utah, Alberta, and Arkansas. *Asaphus? curiosus* Billings, from boulders in the Mystic Conglomerate, Quebec, is referred to the new genus.

INTRODUCTION

COLLECTIONS containing specimens referable to the new genus *Ptyocephalus* were studied many years ago by Dr. E. O. Ulrich. No descriptions were published, but in 1938 (Ulrich and Cooper, pp. 23–24) the name *Billingsura* was proposed and the stratigraphical age and distribution of the new genus discussed. The name *Billingsura* cannot be regarded as valid, because, while *Asaphus? curiosus* Billings was designated as the type, no reference whatever to the original publication was made. It appears that the collection available to Dr. Ulrich included only a very few incomplete specimens of the cephalon, being mainly specimens of the pygidium. In 1940, however, Dr. C. W. Merriam collected an entire specimen, and in 1946 Dr. G. A. Cooper collected two enrolled individuals, and the new genus and species has been founded on these three specimens. I am grateful to Dr. G. A. Cooper for inviting me to study these interesting fossils.

Family ASAPHIDAE Burmeister, 1843

Genus PTYOCEPHALUS Whittington n. gen.

Billingsura Ulrich and Cooper, 1938, *nomen nudum.*

Genotype: *Ptyocephalus vigilans* Whittington n. gen., n. sp.

Diagnosis:—Dorsal shields of small size, largest known *circa* 4 cm. in length; rectangular in outline, more than twice as long as wide; strongly convex, but with anterior and anterolateral, posterior and posterolateral portions flattened. Cephalon quadrangular in outline, glabella without furrows, narrowing forwards. Eyes large, facial suture isoteliform. Occipital ring and posterior border not demarcated, genal angles rounded. Thorax of eight segments. Pygidium pentagonal in outline. Hypostome with oval, convex middle body, broad, wing-like lateral borders and deeply notched posterior border. Free cheeks, preglabellar field, facets of thorax and pygidium, and posterolateral borders of pygidium ornamented with terrace lines. Elsewhere test ornamented with fine, closely and irregularly spaced pits.

Horizon.—Upper Canadian (Lower Ordovician) of Nevada, Utah, Alberta, Quebec, Arkansas.

PTYOCEPHALUS VIGILANS Whittington n. gen., n. sp.

Plate 82, figures 1–7; Plate 83, figures 1–11

The entire trilobite is rectangular in outline, about two and a quarter times as long as wide, moderately convex longitudinally, strongly convex transversely. The highest point is the axial region of the fifth and sixth segments, where the height is half the maximum width. The anterior and anterolateral borders of the cephalon, posterior and posterolateral borders of the pygidium are flattened and slope gently outwards.

The cephalon is quadrangular in outline, the width slightly greater than the axial length. It is strongly convex, the maximum height little less than half the width. The outline of the anterior margin is gently convex forwards, the lateral margins sinuous, converging slightly forwards, the genal

angles rounded. The outline of the posterior margins of the cheeks is gently convex backwards, the posterior margin of the axial region gently convex forwards. The occipital ring and the posterior border are not defined by furrows. A pair of shallow depressions, the axial furrows, run forward from opposite the axial furrows of the first segment to the posterior corner of the palpebral lobes. These depressions continue forwards to the anterior corners of the palpebral lobes, and serve to define the glabella laterally. Anteriorly the glabella is defined by the change in slope between the median and anterolateral parts of the cephalon, which runs in an arc, convex forwards, between the anterior ends of the eyes. The palpebral lobes are flat, sloping gently outwards and forwards. The preglabellar field is flat, sloping gently forwards. The eyes are more than one-third the cephalic length; the anterior end is situated at less than half the length of the cephalon, and the eyes are curved in a semicircle, with a steep convex slope. The lenses are small, circular, and arranged in diagonal lines (Pl. 82, fig. 6; Pl. 83, fig. 6). The posterior branch of the facial suture runs in a curve convex forwards to reach the posterior margin at a point about half the width of the cheeks. The anterior branches run at first outwards, then curve around to run forwards and inwards to meet in an oblique angle at the mid-line just within the anterior margin. Presumably a median suture runs forwards from this point to cross the margin, but the holotype and paratype are damaged and do not show this feature. The free cheeks slope gently anteriorly and anterolaterally, more steeply outside and behind the eyes, with vertical gently convex borders, narrow in front, but widening posteriorly to occupy one-half the width at the margin. The convexity makes the outermost part of the border overhanging (Pl. 82, figs. 1, 3, 4).

The hypostome is in length about half the cephalic length, in width about half the cephalic width. The anterior (sutural) margin is gently curved, the anterior border narrow medially, laterally extended into rounded wings. The middle body is gently and evenly convex, extends from just inside the anterior margin to the base of the posterior notch, and is defined by shallow furrows. The middle furrow is represented by a pair of ovate pits, situated on the margins of the middle body, the long axes directed inwards and backwards. The posterior margin of the pits has the steeper slope. Immediately posterior to the pits are a pair of small, ovate gently convex maculae, of the same size as the pits. On paratype B each of the maculae is crossed by two terrace lines, which are continuous with those on the middle body and lateral borders (Pl. 83, fig. 8). There are no structures suggesting eye lenses on the maculae. The middle furrow divides the middle body into a larger anterior and a smaller posterior lobe, the anterior lobe being three times the size of the posterior. The lateral borders are broad, narrowing backwards, with curved anterior margin, lateral marginal outline converging posteriorly; not continuous with the anterior border but extending outwards at a level ventrad to that of the anterior border

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EXPLANATION OF PLATE 82

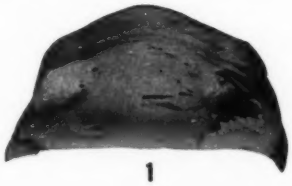
Ptyocephalus vigilans Whittington n. gen., n. sp., unretouched photographs. p. 567)

FIGS. *1–5*—Holotype, anterior, posterior, left lateral, right lateral, and dorsal views, respectively ×4½. North end of Antelope Range, Roberts Mountains Quadrangle, Nevada, about 1 mile south of mouth of Ninemile Canyon, at west base of range. Collected by C. W. Merriam, 1940.

6—Paratype B, enrolled individual, dorsal view of cephalon, anterior portion broken, ×8. The fine, closely spaced dark spots on the glabella and palpebral lobes are the pits in the test, the relatively raised portion between the pits making a reticulate pattern. The eye facets may also be seen.

7—Paratype A, enrolled individual, dorsal view of thorax, ×8, showing the articulating furrow and the articulating half-ring, the articulating processes in the axial furrows, and the ornament on the axial rings and pleurae.

Paratypes A and B from Pogonip formation, north fork of Canyon 3.1 miles northeast of road intersection north of Blair Ranch, 2½ miles southwest of Ninemile Canyon, Roberts Mountain Quadrangle, Nevada. Collected by G. A. Cooper, 1946.



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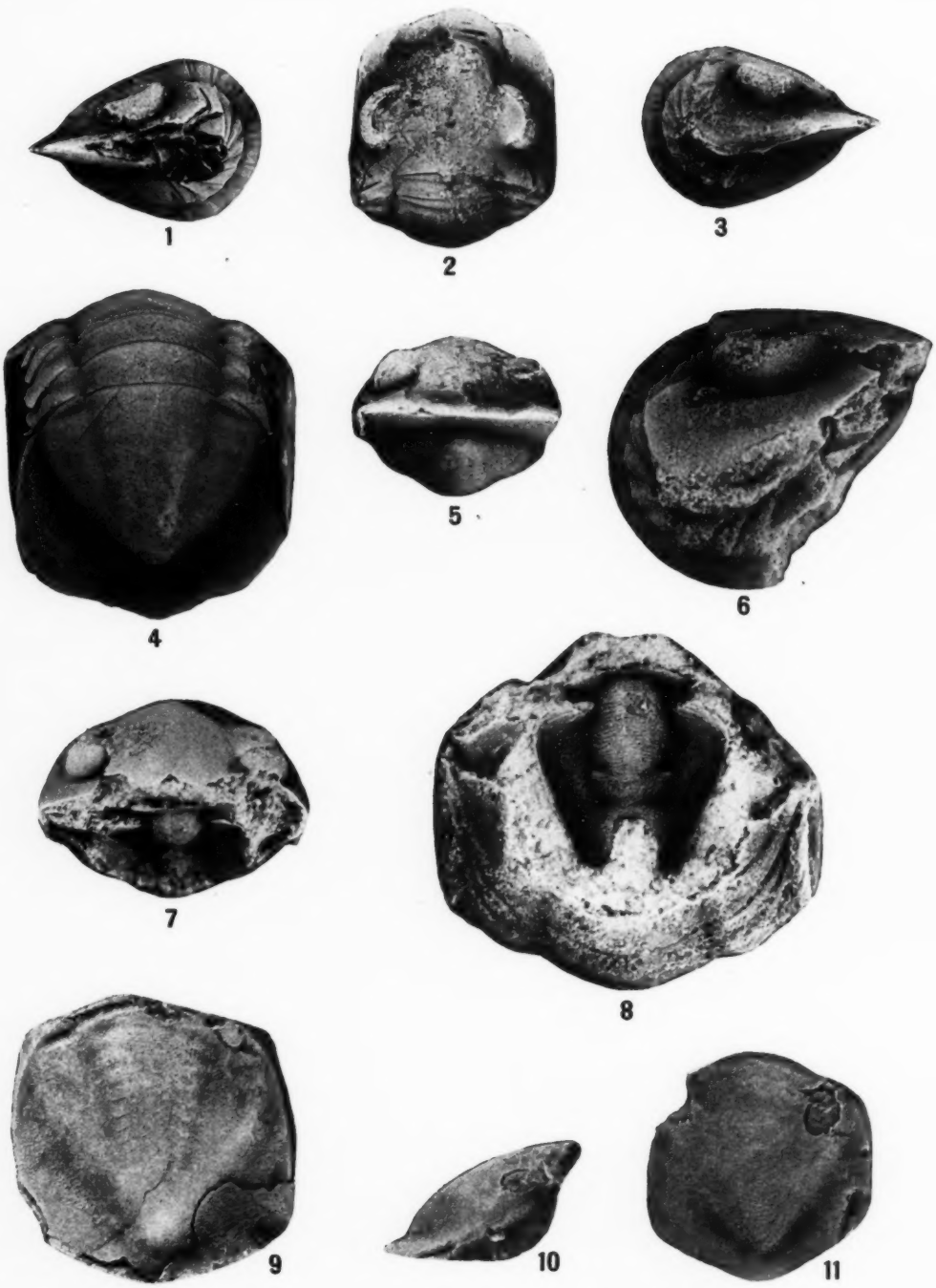
Whittington, Lower Ordovician Trilobite



Whittington, Lower Ordovician Trilobite

(Pl. 83, fig. 7). The outer portions of the lateral borders are ventrally deflected. The lateral borders merge into the posterior border which is deeply notched. The outer parts of the posterior border are flat; the central and inner parts slope downwards and inwards to the notch. The posterior tips and the base of notch are broadly rounded. At the base of the notch the posterior furrow is very shallow. There is no evidence that the hypostome of paratype B is displaced (Pl. 83, figs. 6–8) and the anterior border is in the same plane as the anterolateral cephalic doublure, seen on the left side of Pl. 83, figure 7. A comparison of Pl. 83, figures 6 and 7, shows that the anterior border and wings of the hypostome were situated a short distance directly under the anterior rounded part of the glabella. The anterior cephalic doublure must therefore have been flat, and very close to the flattened anterior part of the dorsal test of the cephalon. The hypostome is directed backwards and downwards, the tips being below and just within the posterior border of the cephalon, and on a horizontal level with the genal angles (Pl. 83, figs. 6, 7). In the enrolled state the hypostome is within the space enclosed by the convex part of the cephalon and the pygidium. As paratype B shows (Pl. 83, figs. 7, 8) the middle body and posterior border with notch are situated under the rachis of the pygidium. The anterolateral margins of the lateral borders approach very close to the inner edge of the flat part of the doublure of both cephalon and pygidium, as seen on the left side of Pl. 83, figures 7 and 8.

The thorax is composed of eight segments all of the same length. The axial furrows are shallow. The axial rings are moderately convex, the articulating furrows shallow. No appendiferal pits can be observed on the dorsal side (Pl. 82, fig. 7). At the anterior margin in the axial furrows is a marked small depression, probably a socket, into which fits a boss on the posterior margin of the next segment forward—an articulating arrangement. The pleurae lengthen outwards, and are inclined steeply downwards outside the fulcrum. The outline of the posterior margin is curved, convex posteriorly. The facet is large, and extends from the inner anterior corner of the pleura across to the outer, posterior margin, with a sharp flexure at the boundary. The very shallow pleural furrows run out diagonally from the axial furrows (parallel to the edge of the facet) and die out at one-third the width. The outer margins of the pleurae are rounded. In paratype A enrolment reveals the articulating half-ring on the first six segments (Pl. 82, fig. 7; Pl. 83, figs. 1, 3). No articulating half-ring is revealed on the last two segments.

The pygidium is pentagonal in outline—the anterior margin gently convex forwards, the lateral margins straight, converging forwards, the posterolateral corners rounded, the posterior margin a broad 'V' in outline, the posterior tip rounded. The pygidium is slightly wider than long, strongly convex, the height being less than half the width. A sharp change of slope runs from the anterolateral corners to the posterior tip of the rachis, and thereby divides the pygidium into two portions. The rachis and adjacent parts of the pleural lobes form a strongly convex portion, the posterolateral and posterior parts of the pleural lobes being

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EXPLANATION OF PLATE 83

Ptyocephalus vigilans Whittington n. gen., n. sp., unretouched photographs. (p. 567)

FIGS. *1–5*—Paratype A, enrolled individual; left lateral, dorsal (of cephalon), right lateral, dorsal (of pygidium), anterior views respectively, ×4, except fig. *4*, which is ×6.

6–8—Paratype *B*, enrolled individual with the anterior part of the cephalon and the pygidium cut away to reveal the hypostome. Right lateral (×8), anterior (×6), and ventral (×8) views respectively.

Paratypes A and B from Pogonip Formation, north fork of Canyon, 3.1 miles northeast of road intersection north of Blair Ranch, 2½ miles southwest of Ninemile Canyon, Roberts Mountains Quadrangle, Nevada. Collected by G. A. Cooper, 1946.

9—Exfoliated pygidium, dorsal view, ×3.

10–11—Pygidium, lateral and dorsal view, ×3.

Both from Pogonip formation, west front of Antelope Range, 2½ miles south of Ninemile Canyon, Roberts Mountains Quadrangle, Nevada. Collected by E. Kirk.

flattened and sloping gently outwards and backwards. The rachis is defined by very shallow furrows, and narrows back to a rounded termination. An exfoliated specimen (Pl. 83, fig. 9) shows ten pairs of oval depressions (in the ventral side) extending in from the axial furrows to about one-third the width, except the first pair which extend right across the rachis. These depressions are very faintly indicated anteriorly on the dorsal surface of the test. Presumably the depressions are areas of muscle insertion. The first pair of pleural furrows are shallow, and extend about half way down the slope of the pleural lobes. The facet is large, with a curved anterolateral margin, and flexed strongly down, almost vertical, extending from the axial furrow around to the posterior tip of the lateral margin, the maximum width being at the anterolateral corners. The articulating half-ring is very short.

A comparison of Pl. 83, figures 1–5 with Pl. 82, figures 3, 4 shows the enrolment. The large facets of the pygidium and pleurae are overlapped by each other successively forwards, and the steep outer parts of the free cheeks embrace all the pleural and pygidial facets. The anterior and anterolateral borders of the cephalon and the posterior and posterolateral borders of the pygidium are thus brought into contact, and the lateral margins of the free cheeks lie against the lateral margins of the pygidium (i.e. the inner edge of the facets). This enrolment implies that the doublure of the flattened anterolateral part of the cephalon, and the posterolateral part of the pygidium must be flat, and very close to the dorsal test, as the position of the hypostome also indicates (see above). Specimens in the collections suggest that the doublure of the pygidium is flexed upwards under the convex part, and continues for a short distance.

The glabella, palpebral lobes, axial rings and pleurae of the thorax, the rachis and the convex parts of the pleural lobes of the pygidium are ornamented with very fine closely spaced pits. The ridges between the pits make a reticulate anastomosing pattern (Pl. 82, figs. 6, 7; Pl. 83, fig. 4). On the pre-glabellar field and free cheeks the ornament is of anastomosing terrace lines tending to run roughly parallel to the anterior margin, i.e. transversely on the free cheeks. On the steep borders of the free cheeks the terrace lines run parallel to the posterior margin. At the inner margin of the facets of the thorax and pygidium the terrace lines run parallel to this margin, but elsewhere are arranged transversely on the pygidial facets and longitudinally on the thoracic facets. On the flattened lateral and posterior part of the pygidium terrace lines run transversely and roughly parallel to the posterior margin. The hypostome is crossed by transverse terrace lines extending continuously across the lateral borders, middle body and maculae (Pl. 83, fig. 8). The pygidium shown in Pl. 83, figures 10, 11, does not exhibit the pitted ornament, the terrace lines running transversely across the rachis and convex parts of the pleural lobes, roughly parallel to the posterior margin. This may be because the specimen is partly exfoliated, or because it may represent a different species. An imperfect enrolled individual from the same locality, of length ca. 4.0 cm., shows the same pitted ornament as the types.

Dimensions.—All measurements are expressed in millimeters, and length and width are measured as projections on to the horizontal.

Holotype

Axial length	20.5
Maximum width (just in front of genal angles)	9.0
Axial height at highest point (6th segment)	4.5
Axial length of cephalon	7.0
Axial height of cephalon at posterior margin	3.75
Axial length of glabella (plus occipital ring)	6.0
Maximum width of glabella (at base)	4.5
Length of eyes	3.0
Distance of anterior margin of eyes from anterior margin of cephalon	3.0
Width of axial ring of 4th segment (the widest)	4.5
Width of 4th segment (the widest)	8.5
Axial length of pygidium	7.0
Maximum width of pygidium (at posterolateral corners)	8.0
Axial height of pygidium at anterior margin	3.5
Length of rachis of pygidium	5.5
Maximum width of rachis	4.0

Paratype A

Maximum width of cephalon	c. 8.0
Axial length of glabella	5.5
Maximum width of glabella	4.25
Maximum width of pygidium	7.0
Axial length of rachis of pygidium	5.0
Maximum width of rachis of pygidium	3.5

Paratype B

Maximum width of cephalon	7.0
Length of hypostome	3.5
Maximum width of hypostome	3.4
Length of middle body of hypostome	2.0
Width of middle body of hypostome	1.5

Isolated pygidium (see Pl. 83, figs. 10–11)

Axial length	11.5
Maximum width	11.5
Maximum height	5.0

The size of the isolated pygidium shown on Pl. 83, figure 9 suggests that the largest adult individuals would reach a length of more than 3.0 cm., and one imperfect enrolled specimen from the same locality has a length of ca. 4.0 cm. No larger individuals have been collected from any of the localities.

Types, Horizon, Localities.—Holotype from Pogonip formation, north end of Antelope Range, Roberts Mountains Quadrangle, Nevada, about one mile south of mouth of Ninemile Canyon at west base of range.

Paratypes, two enrolled individuals referred to herein as A and B, both from Pogonip formation, north fork of Canyon 3.1 miles northeast of road intersection north of Blair Ranch, 2½ miles southwest of Ninemile Canyon, Roberts Mountains Quadrangle, Nevada.

The types are in the U. S. National Museum.

Discussion.—The isoteliform and opisthoparian dorsal facial sutures, lack of transverse furrows on cephalon and pygidium, large eyes, and thorax of eight segments, suggest that this genus should be referred to the Asaphidae.

It is to be regretted that the type specimens are all damaged at the anterior border of the cephalon, and that therefore the median suture (if it is present) cannot be seen. In *Isotelus* and all other genera with the isoteliform suture the anterior branches curve forward and meet at an oblique angle on the dorsal surface at the midline, and then continue across the doublure as the median suture. In *Ptyocephalus* the anterior branches meet at an oblique angle, and the presumption that a median suture exists is strong. In genera without a median suture, e.g. *Nileus*, the anterior branches unite across the pre-glabellar field in a smooth curve.

The hypostome of *Ptyocephalus* has an outline that is unique among asaphids with notched hypostomes. The anterior part of the lateral borders is the widest, extending out far beyond the anterior wings, and the width of the hypostome is reduced rapidly behind this point. In most of the genera with notched hypostomes the maximum width is across the anterior wings, and the greatest width across the lateral borders is near the mid-point. In many asaphids with notched hypostomes the terrace lines run longitudinally on the lateral and posterior borders, and concentrically or sometimes transversely on the middle body, e.g. in *Asaphus* (see Brögger, 1886, Pl. 1, fig. 2). In *Ptyocephalus* the terrace lines run transversely and continuously across the lateral and posterior borders and middle body. As Brögger (1886, Pl. 2, figs. 28–37; Pl. 3, fig. 40) and Lindström (1901, Pl. 5, figs. 13, 18, 19, 23) have shown, ornament of this type is seen in the hypostomes of *Niobe, Nileus*, and *Symphysurus*. The hypostome of *Niobe* is very unlike that of *Asaphus*, while *Nileus* and *Symphysurus* are not asaphids.

The thorax of *Ptyocephalus* is characteristic of asaphids in form, but the large facets of the pygidium, extending along the lateral margins, and the steep posterolateral parts of the free cheeks which envelop these pygidial facets (Pl. 83, figs. 1 and 3) are unusual. Terrace lines are a characteristic ornament of the test of many trilobites, especially on the facets and doublure. An ornament of shallow pits[1] of varying size and arrangement occurs in other asaphid genera, and in other families of trilobites, e.g. Illaenidae.

In addition to the distinctive features already noted, *Ptyocephalus* differs from all other asaphid genera known to me in the unusually small size, rectangular outline, and relatively strong convexity combined with flattened terminations of the dorsal shield. The quadrangular outline of the cephalon and pentagonal outline of the pygidium are unique. The genus is referred tentatively to the Asaphidae, which family is very broadly defined at present (cf.

[1] I have preferred to use the term pit, and not puncta, since it has not been demonstrated to my knowledge that in asaphids these pits are the outer ends of canals penetrating the test.

Reed, 1930). The subfamily division proposed by Raymond (1910, pp. 61–62) into types with an entire and types with a forked hypostome, is too broadly conceived for present use. No genus closely related to *Ptyocephalus* appears to be known.

The characteristic pygidium of the genus was long ago recognized by Walcott in the upper Pogonip of Nevada as *Asaphus? curiosus* (1884, p. 98, Pl. 12, fig. 15). Collections in the U. S. National Museum show that pygidia similar to that of *Ptyocephalus vigilans*, though possibly representing different species, occur at the following localities in the Upper Canadian: Upper Garden City limestone, on the east side of the Dugway Mountains, and in Logan Canyon, Utah. High Canadian, Goodwin Canyon, Eureka District, Nevada. Smithville formation, vicinity of Smithville, Arkansas. Sarbach formation, northeast spur of Fossil Mountain, Alberta, Canada. The examination of plaster casts of the types of *Asaphus? curiosus* Billings (1865, p. 318, fig. 305 on p. 317) from "Stanbridge, range 6, lot 20, Quebec group" has demonstrated that Billings' figure was a composite reconstruction based on fragments of several pygidia, all somewhat distorted. The pentagonal outline, characteristic form with the flattened posterolateral and posterior portions, and the form of the doublure, indicate that *Asaphus? curiosus* should be referred to *Ptyocephalus*. Billings' specimen came from boulders in the Mystic Conglomerate, and the horizon is therefore not known.

The stratigraphic range and distribution of "*Billingsura*" given by Ulrich and Cooper (1938, p. 24) were evidently based on the same material. It should be noted that only from the localities in the Pogonip of the Antelope Range, Nevada, is the cephalon and thorax of *Ptyocephalus* known. Thus the distribution given above is based on the assumption that the distinctive pygidium is always associated with the same type of cephalon. Further collecting should establish the validity of this assumption, and confirm the value of *Ptyocephalus* as a guide fossil to the Upper Canadian.

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POSTSCRIPT

When this paper was in press a copy reached London of a paper by T. Kobayashi entitled "Two new trilobite genera, *Hamashania* and *Kirkella*" (Geol. Soc. Japan Jour., vol. 49, 1942, pp. 118–121; also Trans. Palaeont. Soc. Japan, no. 142). I am indebted to Dr. C. J. Stubblefield for drawing my attention to this publication. Kobayashi proposes the genus *Kirkella* with *Asaphus ? curiosus* Billings, 1865 as type. As has been remarked above, *Kirkella curiosa* is known only from fragmentary pygidia, but it seems most probable that this distinctive pygidium may prove to be associated with the same type of cephalon as that of the new species from Nevada. This may mean that *Ptyocephalus* is a synonym of *Kirkella*, but uncertainty upon this point must remain until the cephalon is collected from Billings' original locality. It would perhaps be best to use in the meantime *Kirkella?* and not *Ptyocephalus* for the Nevada and other species not from the type locality.

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A SYSTEMATIC REVISION OF *DAPHOENUS* AND SOME ALLIED GENERA

JEAN RINGIER HOUGH

ABSTRACT—A revision is made of the genus *Daphoenus* and a new, very small species described. Hatcher's genera, *Proamphicyon* and *Protemnocyon* are redescribed from additional specimens in the U. S. National Museum. *Daphoenus dodgei*, known only from lower jaws, is referred to a new genus, *Daphoenocyon*, based on two specimens from the Lower Brule, both complete skulls with articulated lower jaws, one associated with a partial skeleton.

Daphoenus and the related genera described in the paper, are shown to be distinct from the typical Canidae represented by *Pseudocynodictis*, *Nothocyon* and the John Day canids. It is suggested that notwithstanding the great amount of parallelism and convergence between the two groups the differences in the auditory region, proportions of the skull and details of the dentition, as well as the general evolutionary trends in the two groups, are sufficient to warrant placing them in separate families. The family Daphoenidae, while remaining conservative in limb structure and dentition, evolved more rapidly in size, culminating in the gigantic bear dogs of the Arikarean. The more typical Canidae attained the characteristic canid specializations very early and after a minor radiation in the John Day, provided the direct ancestry through *Tomarctus* of all of the living canids.

INTRODUCTION

Daphoenus was one of the earliest fossil carnivores to be described. Very complete accounts of the genus have been given by Leidy (1889), Scott (1898) and Hatcher (1902). As is often the case, however, with fossil genera that have been known a long time and written about a great deal, the taxonomy of the species and allied genera is in a state of confusion. The most recent and authoritative work on the subject, Scott and Jepsen's monograph on the White River Carnivora (1936), while it sums up much of the earlier generic descriptions makes no attempt at a critical revision. In fact, the authors state that they consider such a revision virtually impossible because fossil species are indeterminable.

In the writer's opinion, this viewpoint, which was perhaps more that of the senior than the junior author, confuses the entire problem. Actually we know no more of fossil genera than we do of fossil species. We feel that we do because of the common practice of defining a genus by means of fixed characters. This is, in effect, erecting an archetype (Simpson, 1941). In paleontology an archetype is often based on a few specimens, or even a purely imaginary individual composed of parts of three or four. It is as if, having the skull of a negro, the postcranial skeleton of a Chinese, and the dentition of a Caucasian, we defined the genus *Homo* from the characters of this composite and then claimed we could tell nothing of human races. In defining a genus in this way we have obscured the variation by which we could have determined the races and the practice gives a false sense of a genus being real, by which we mean static and definable and the species, unreal, that is, undefinable.

Actually our knowledge is of individuals. With such and such a specimen before us, complete or incomplete as the case may be, we can confidently say that an animal with those characteristics existed in a given locality at a given geologic period. The taxonomic status of a group of such individuals can only be ascertained by a careful study of all of the characters of all of the individual specimens available. If only one is known, as is often the case in paleontology, then the definition must be loosely drawn (Simpson, 1941). In this way paleontology can be truly an inductive science, where the older methods tended to make it deductive, i.e., a genus was defined and individuals referred to it instead of the taxonomic grouping being determined by a study of individual variation.

In the case of *Daphoenus* and the allied

genera the writer believes that the difficulty of determining species has largely resulted from the use of the older methods. This work is an attempt at a different approach. There is no claim to completeness, although every attempt has been made to examine all specimens possible. The study was made possible by a grant from the Geological Society of America and the writer wishes to thank the Society and the staffs of the various museums in which the work was done for their most gratifying cooperation. Thanks are due especially to Dr. G. G. Simpson of the American Museum of Natural History not only for the courtesies of the Museum but for valuable criticism of the manuscript; to Dr. C. L. Gazin of the U. S. National Museum for permission to study and describe certain hitherto undescribed specimens in the U. S. National Museum, which proved very significant, and also for help with the organization of the material; to Dr. John Clark of the Carnegie Museum; and to Dr. E. C. Olson of Walker Museum, the University of Chicago.

THE SYSTEMATIC POSITION OF *DAPHOENUS*

The Oligocene Canidae are usually thought of as being divided into two tribes or subfamilies which are distinguished by certain characters of the auditory region and by size. *Daphoenus* and the allied genera which form the subject matter of this paper are usually considered the larger forms, *Pseudocynodictis*, the smaller. There is no doubt as to the distinction of the auditory region in the two groups, but two small skulls in the American Museum collection seem to disprove the hypothesis of size distinction.

These skulls which are those of small carnivores about the size of the fennec were collected together from the same locality, Scenic, South Dakota. The one, associated with a lower jaw and a considerable part of the skeleton is *Pseudocynodictis gregarius*, the other a small species of *Daphoenus* with all of the differences in proportions and details of the dentition characteristic of the larger forms.

Pseudocynodictis, as shown by the writer in an earlier paper (Hough, 1948) is unmistakably canid. *Daphoenus* is not, its auditory region being in all respects as divergent as possible from that of *Canis*. The broad basioccipital and narrow auditory cavity, the pear-shaped promontorium, the small bullae are all viverrid characters. The dentition resembles that of *Canis* in a general way but differs in the details. The postcranial skeleton is more that of the Felidae than the Canidae. Moreover, these distinctions, present in the Oligocene genera, become more pronounced in the Miocene forms. The evolutionary tendencies of the two groups are entirely divergent. The *Pseudocynodictis* phylum continues the typical canid adaptations bringing them together in more and more effective combinations until by the Pliocene *Aelurodon* and *Tomarctus* lack little of being congeneric with *Canis*.

The members of the *Daphoenus* group, on the other hand, while evolving rapidly in size remain conservative in dentition and limb structure. The auditory bullae are always small, but in the large Miocene forms take on a flask shape which with the thick floored meatus and broad expanse of the base of the paroccipital process produces a very bear-like aspect. The tendency toward a plantigrade gait increases with the increase in size and the limb girdles also tend to take on ursid features.

The correct picture of the relationship of *Daphoenus* and *Pseudocynodictis* would not seem to be, therefore, that of two tribes of canids, one large and one small, both contributing to the ancestry of modern forms but of two separate groups of carnivores evolving in different ways at different rates. The *Pseudocynodictis* group developed the typical canid specializations very early in the auditory region, in the limbs and in the dentition. In these features they were well in advance of the daphoenids. The latter developed more rapidly in size. All of the Oligocene canids of the typical group, including *Phlaocyon*, are relatively small and did not attain large size until the Arikarean, at which time the daphoenid group had given rise to the gigantic bear dogs.

The best recognition taxonomically of the unity of the group and its divergence from the typical Canidae seems to be to give it family rank as the Daphoenidae. There are two other possibilities. The one is to consider

it a subfamily of the Canidae, as has usually been the practice in the past. Much can be said for this arrangement. In spite of the clear-cut divergence pointed out before, which will be discussed more at length later in the paper, there is abundant evidence of close relationship. The ancestry of all of the Fissipedia can probably be traced to the Quercy Miacidae, Cynodontoides, Cynodictoides and Stenoplesictpodes as defined by Teilhard de Chardin, or to closely similar American forms. The Quercy carnivora intergrade in dentition in such a way that a group such as the Stenoplesictoides characterized by a small viverrid-like auditory bulla, show a gradation in dental pattern from that paralleling the typical Felidae at one extreme to one indistinguishable from *Pseudocynodictis* at the other.

The Cynodontoides and Cynodictoides show similar gradations. Presumably *Daphoenus* originated from one of these groups, probably the Stenoplesictoides, *Pseudocynodictis* from another, perhaps the Cynodictoides so that the common ancestry is very close.

This genetic similarity is strikingly brought out by the large amount of parallelism and convergence in both lines. In the *Daphoenus* group the auditory bulla when present, is always small, and anteriorly placed. In the John Day *Paradaphoenus*, however, an approach to the large bulla of the typical Canidae is made, since the bulla of *Paradaphoenus*, while still relatively small is more highly inflated, and extends more posteriorly than in any of the earlier genera. In *Daphoenodon* from the Lower Harrison the bulla is flask-shaped with a well developed tubular meatus. *Enhydrocyon*, a typical canid of the John Day approaches such a structure, at least superficially. The bulla is smaller than in the contemporary mesocyons and there is a short tubular meatus.

There are similar examples of convergence in the limbs and dentition. The limb structure of the Daphoenidae is always conservative and there is never any approach to the characteristic cursorial adaptations of the true Canidae. The convergence in this instance is the other way. *Mesocyon hortilurosae* is sufficiently close to *Canis* in the structure of the humerus as to have lost the entepicondylar foramen. *Mesocyon coryphaeus* on the other hand, tends to develop a heavier, more mustelid type of limb which parallels some of the features of the daphoenids. The dentition of many of the *Daphoenus* genera becomes more canid in the shape and shearing efficiency of the carnassial, the reduction of the molar dentition, the loss of M^3 and other features. Particularly *Daphoenus hartshornianus* is strikingly like the true Canidae in certain aspects of the upper molars, especially the configuration of the cingulum. Trenchant heels to the lower sectorial are acquired in several genera in both groups, *Tempocyon* and *Enhydrocyon*, for example, in the typical Canidae, *Protemnocyon* and *Daphoenocyon* in the Daphoenidae.

It is this widespread parallelism between the members of the *Daphoenus* group and the typical Canidae which has given rise to the conflicting phylogenies. Scott, for example, based his view of the ancestry of the modern Canidae on just these correspondences, deriving the Caninae from *D. hartshornianus* through *Mesocyon* and *Tomarctus* and the Cyoninae from *Protemnocyon* through *Temnocyon*. He also followed Loomis' suggestion that *Brachyrhynchocyon* is ancestral to *Enhydrocyon*. In the writer's opinion this phylogeny is wholly false and ignores the essential unity of the groups in question. The fact, however, that such assumptions could be made by competent authorities is illustrative of how strong the parallelism and convergence is, and this in turn is evidence of a close relationship between the two groups. It could be used as an argument for considering the *Daphoenus* group a subfamily of the Canidae rather than a separate family as is done in this paper.

The writer believes, however, that the family arrangement brings out the relationship of the Daphoenidae to the later Canidae more clearly and also gives a better understanding of relationships within the group itself. The range of variation is really greater than is at all usual in a subfamily as these are now delimited, and much more analogous to that of a family among recent carnivores. The size range for example, from that of animals as small as *Fennecus zerda* to those as large as a small wolf is about that

of the recent Canidae. The range in dentition is greater than in such uniform families as the Canidae and Felidae, but approximates such a heterogenous assemblage as the Viverridae or Mustelidae. There is even more variation in the canine than is usual in any carnivore family. The range in limb structure is similar to that of the Felidae although very much less than that of the Mustelidae.

Probably the most pronounced difference between the group and members of the living carnivore families, however, is the range of brain capacity. The difference between the low braincase of the more typical *Daphoenus vetus* specimens and the relatively inflated structure of *D. hartshornianus* and *Protemnocyon inflatus*, both of which were contemporary with it, is as great as from the latter to the large cranium of the modern Carnivora. It is evident that even in the relatively short time, geologically speaking, of the Lower Brule, they were evolving rapidly in this respect.

The variation within the group is, therefore, certainly more analogous to that of a family than a subfamily, and while the distinction from other groups may be somewhat less pronounced, as would be expected in primitive forms, the writer believes that separation from the Canidae is advisable and that scheme of classification is followed in this paper.

There is still another possibility in the matter of classification, although this seems less feasible than either of the other two. All of the Oligocene "canids" could be united in one primitive subfamily. This has been discussed by Simpson (1945). It has all of the inconveniences attendant on any horizontal classification, the most important of which is the difficulty in determining a point in the vertical sequence at which a separation may be made. *Pseudocynodictis* resembles *Nothocyon* more closely than it does *Daphoenus* and the latter in turn is closer to *Paradaphoenus* than to *Pseudocynodictis*. *Nothocyon* grades into *Mesocyon* which, in turn, is closely similar to *Tomarctus*. Grouping the Oligocene genera together, therefore, while possible if only these genera are considered, presents difficulties when later forms must be included.

On the whole a family grouping seems the best solution. Argument could also be raised as to the number of genera, and this again is largely a matter of subjective judgment. The reason for the distinction of the genera recognized in this paper will be given in the discussion following the descriptions. Almost the maximum number are recognized and this may seem excessive splitting. The writer believes, however, that while there is a tendency on the part of some recent taxonomists to erect too many genera, this is not usually the case in paleontology. The distinctions with which a paleontologist deals are necessarily deep-seated and genetically complex. Moreover, the time involved is very long compared with that of any studies which can be made with Recent mammal populations. The Lower Brule covered approximately 1½ million years. It is impossible that, during that time, genetic changes would not accumulate which would be sufficient under normal conditions to split up any evolutionarily vigorous stock into many divergent genera and even families.

The exact lines where the distinction of genera are to be drawn are, of course, a different matter and the arrangement made in this paper is by no means to be considered final. The definitions are made as they are primarily to bring out the evolutionary tendencies within the Daphoenidae and especially to point out the parallelism with similar tendencies in the more typical Canidae.

Family Daphoenidae

Small to very large sized carnivores which combine a generalized canid dentition and elongate skull with a predominantly feline postcranial skeleton. Known to have existed throughout the Oligocene and lower Miocene periods of Colorado, South Dakota, Nebraska and Wyoming. The diagnostic characters are described below.

Skull.—Muzzle and facial region short, cranium and basicranial region elongate, except in the two brachycephalic genera; elongation of basicranium due to the distance from the paroccipital to the condyle; sagittal crest high in the larger forms, low in the smaller species, always bifurcating abruptly at the point of greatest constriction of the cranium or just anterior to it; occipital crest high in all genera.

Dentition.—Except in the one genus *Daphoenocyon* P^1 and P^2 are simple, without accessory cusps and separated from each other by a diastema. P^4 is persistently primitive with an oblique shear and imperfectly separated antero-internal cusp. In some genera there is a tendency to parallel the more typical Canidae in the development of a straighter and higher shearing surface, and a more anterior position of the antero-internal cusp. The external cusps (paracone and metacone) of M^1 are well set in from the margin of the tooth and with the inner cusp (hypocone) which is a low crest rather than a distinct cusp, form a broad triangle. The external cingulum is well developed and produced into a cuspule at the antero-external corner of the tooth. The internal cingulum is very broad and equally well developed anteriorly and posteriorly and in most cases is without the asymmetry of the typical Canidae. In some genera there is a tendency to parallel the Canidae in this feature. M^3 is usually present. In one group of genera there is a tendency for its reduction and loss but in another, the *Daphoenodon-Amphicyon* phylum, the molar dentition tends to become more massive and M^3 is retained.

Auditory region.—The basioccipital is always broad, the auditory region proper narrow. The exoccipital extends anteriorly to the base of the promontorium and always forms, except in *Daphoenocyon*, nearly one-third of the basicranium. The paroccipital process is flattened and triangular in shape, extending horizontally backward with a slight medial curve. The mastoid is nearly always large and in the larger forms produced into a rugose process. The facial nerve passes through a foramen piercing a ridge of bone which connects the medial margin of the mastoid with the promontorium and leaves the skull through a groove cutting diagonally across the mastoid process. The promontorium is small and pyriform except in *Daphoenocyon*. The auditory bullae are always small and anteriorly placed when present. In the Oligocene genera and *Paradaphoenus* the bulla is an inflated ring resembling the anterior chamber of the bulla in *Nandinia;* in the *Daphoenodon-Amphicyon* group it is flask-shaped, with features paralleling those of the bears.

Postcranial skeleton.—Most features of the skeleton are closely similar to those of the lynx. There are none of the typically canid characters. The scapula resembles that of a bear in (1) the width of the neck and outline of the vertebral border and (2) in the presence of a broad process adjacent to the axillary border which makes the infraspinous fossa seem divided into two very unequal parts. The characters of the pelvis are a mixture of canid, ursid and felid features. In the Canidae the blade of the ilium is expanded to form a broad wing, the acetabulum faces more downward than outward and the pubes form a broad, shallow arch. The ischium is inclined laterally to form the upper margin of the arch and its posterior end is produced into a strong tuberosity. In the cat, the ilia are slender, straight blades lying parallel to each other, the acetabulum is directed downward as in *Canis* but the pubic arch is deep and narrow with the ischia continuing in a straight line from the ilia and lying parallel to one another. In the bear the very massive pubic arch is both wide and deep. The ilia are hugely expanded with deeply concave outer surfaces. The acetabulum is directed outward more than downward and the ischia terminate in enormous tuberosities. The shape of the ilia in *Daphoenus* more resembles that of *Felis* than *Canis* or *Ursus*. The blade is broader, however, and the gluteal surface more deeply concave. The acetabulum faces outward as in the bears, and the inner upper margin of the ilium where it forms parts of the acetabulum is curved as in the bears. The shaft of the ischium is in line with the acetabulum as in *Felis*, but because this part curves outward the two ischia are further apart and the pubic arch broad.

Genus Daphoenus

This genus includes both the largest and smallest forms and is the most generalized and variable of all of the Daphoenidae. In fact, the genus could be characterized rather by the absence of the specializations which mark the other genera than by any particular set of distinctive characters.* The braincase is low to highly inflated; the sagittal crest low to very high. The canine varies from a short, stout, straight tooth with an oval cross section to the more compressed,

slender and recurved type characteristic of *D. hartshornianus*. The muzzle is always slender and tapering without any pronounced constriction. The premolars are simple, the anterior ones well spaced. P^1 and P^2 have no accessory cusps. The molar index ranges from 130 to 150. M^1 varies from a symmetrically sub-rectangular tooth to one of a more triangular shape with a tendency toward the asymmetry of the more typical Canidae. The heel of the lower sectorial is basined to semi-trenchant.

Genus Proamphicyon

The size is that of the larger *Daphoenus* species. The typical features parallel to some extent those of *Amphicyon*, the long compressed canines with cutting edges for example, and the relatively narrow palate and long, narrow muzzle constricted sharply at the base of the first premolar but curving outward again at the base of the canine. The carnassial is proportionally larger than that of *Daphoenus*, the shear is more oblique, the internal cusp more prominent, not extending anteriorly beyond the median cusp, which is high and rounded. The molars are elongate, M^2 larger than in *Daphoenus*, M^3 a small oval tooth.

The basicranial region is unusually long from the postglenoid process to the paroccipital. The braincase is small, the sagittal crest high, bifurcating anteriorly of the greatest constriction of the cranium.

The dentition is very like that of *Daphoenodon* but the proportions of the skull are quite different. Only one species is known. It is possible if more specimens were at hand, there would be greater variation and that *Daphoenodon* may be derived from a member of this group.

Genus Protemnocyon

The members of this genus are about the size of *D. hartshornianus*. The braincase is highly inflated while the sagittal crest which is low, bifurcates almost precisely at the point of greatest constriction of the cranium. The muzzle is relatively short with no decided constriction. The basicranial region is relatively short. The frontal sinuses are prominent, this being an important point of distinction from *D. hartshornianus*. The canines are stout and broad based, with a rounded oval cross section. The premolars are simple. P^1 and P^2 are well spaced from each other and P^3. The carnassial is large, the internal cusp is in line with the shear and extends anteriorly to a level with the anterior margin of the tooth. The median cusp is more compressed than in *Proamphicyon* and has a shearing inner surface. The heel of the lower sectorial is strongly trenchant, with a higher median cusp.

Genus Brachyrhynchocyon

This genus is characterized by extreme facial shortening. The premolar-molar series occupies only 30% of the length of the skull whereas in *Daphoenus* they occupy 37%. The premolars are crowded and P^1 is reduced to a vestige. The canine is a short stabbing tooth. M^2 is much reduced and M^3 absent. The heel of the lower sectorial is trenchant.

Genus Daphoenocyon

This genus, described below, is closely related to *Brachyrhynchocyon* but is larger and has a very short cranium as well as face. The basicranial region is also very short. The lower jaw is short and thick. The premolars are crowded but not reduced. The frontal sinuses are prominent and this together with the rounded cranium gives the skull some resemblance to that of a domestic dog. The promontorium is large and rounded. The mastoid is produced into a rugose knob. The facial nerve apparently left the skull posteriorly of the mastoid process. Accessory cusps are present on P_2 and P_3 as well as P_4. The molars are triangular with little development of the internal cingulum. M^3 is a small rounded tooth situated in the angle of the jaw.

Genus Daphoenodon

This is a lower Miocene genus of larger animals than in the Oligocene genera. It is extremely like *Daphoenus* and *Proamphicyon* in the dentition and postcranial skeleton. The auditory region is very characteristic. A small anteriorly placed bulla is present, which is flask-shaped with a downward-curved tubular meatus. The features of the middle ear are closely similar to those of *Daphoenus*. The floor of the auditory

FIG. *1*—*Daphoenus vetus* (Leidy), dorsal and ventral views of the skull, ×0.5. *1, 2*, AMNH 11857. *3, 4*, AMNH 9757.
(p. 580)

meatus is very thick and filled with cancellous bone much as in the living Ursidae. The hypotympanic sinus extends along the sides of the meatus, a characteristic which is also typical of the Ursidae.

The plantigrade features of the skeleton of *Daphoenodon* are further developed in connection with the larger size.

Genus Amphicyon

The genus comprises one group of the gigantic bear dogs. The proportions of the skull are quite different from those of *Daphoenodon*. The muzzle is long and slender, the palate narrow. The canines are recurved with compressed cutting edges. The molar dentition is massive with M^3 present and large. The auditory bulla is very like that of *Daphoenodon*, flask-shaped, with a long tubular curved auditory meatus. The hypotympanic cavity extends along both sides of the meatus which is produced so far into the cavity of the bulla as to floor the middle ear so that the tympanic bullae are in a sense false bullae without any connection with the sound-producing apparatus (Hough, 1948).

The postcranial skeleton is a mixture of feline, canine and ursine characters with the felid features predominant. The ursid characters are largely parallelisms developed in connection with the plantigrade gait.

Genus Paradaphoenus

This is a small lower Miocene form not much larger than *Daphoenus minimus*. It is probably derived from it. The braincase is more inflated, the muzzle longer and narrower, and there is a small, ring-shaped auditory bulla.

The carnassial has developed a somewhat more efficient shear than that of the Oligocene form and the molar dentition is more massive. The cingulum is developed both anteriorly and posteriorly on the internal margin of M^1 so that the tooth is quadrate. M^2 is almost as large as M^1, M^3 is present. The muzzle is more elongate than in *Daphoenus minimus* and the palate narrower. The basicranial region is long and narrower than in most daphoenids.

Descriptions of Species

Daphoenus vetus (Leidy)

Text figures 1, 2, 3.1, 3.2

Amphicyon vetus Leidy, 1853, Proc. Acad. Natural Science Philadelphia, 1853, p. 393.

Specific characters.—Size that of a coyote or small wolf; skull 170 mm. to 205 mm. maximum length (tip of occipital crest to premaxilla); proportions of the skull approximately those of *Paradoxurus*. Sagittal crest high, braincase low to moderately inflated. Canines stout and short, protruding forward and outward with a tendency in some specimens toward a more slender curved type. Molars subquadrate in outline. Cingulum symmetrical. Heel of lower carnassial semi-trenchant.

Type.—U. S. National Museum no. 658.

Locality and horizon.—South Dakota (exact locality not stated) Orellan.

Specimens examined.—CNHM[1] P 12021, Chamberlain Pass, S. D.; AMNH no. 11857, 9759, 12451, Corral Draw, Big Badlands, S. D.; AMNH no. 29098, Scenic, S. D.; USNM, no. 658 (type) Mauvaises Terres, S. D., no. 5921, Cheyenne River, S. D.; CM no. 492, Sioux Co., Nebr.

Description of specimens.—The type of this species which is also the type of the genus is a specimen in the U. S. National Museum (no. 658) which consists of the posterior portion of a skull and left zygomatic arch. The basicranial region is well preserved. The sagittal crest is broken off throughout its entire length and the posterior portion of the upper part of the skull damaged. The posterior portion of the lower jaw and a lower M_1 from the left jaw are associated with the skull. The specimen is small and possesses, as Leidy (1853, 1869) pointed out, very much the proportions of *Paradoxurus*. The distinctive characters are: the small low braincase, the sharp constriction of the cranium like that of the Viverridae—and very unlike *Canis*—the broad zygomatic arch and the characteristic auditory region with the small, anteriorly placed

[1] CNHM = Chicago Natural History Museum; AMNH = American Museum of Natural History; USNM = United States National Museum; CM = Carnegie Museum.

Explanation of Plate 84

Figs. *1*, *2*—*Proamphicyon nebraskensis* Hatcher, USNM 17842. *1*, ventral view. *2*, side view, both ×0.65. (p. 591)

Hough, *Daphoenus* and Allied Genera

Hough, *Daphoenus* and Allied Genera

bulla closely resembling that of *Nandinia*.

Chicago Natural History Museum specimen P 12021, an exceptionally well preserved skull, the auditory region of which was described by the writer in a previous paper (Hough, 1948) shows all of the typical daphoenid features. The size is that of a large coyote and the skull proportions those typical for the species. This is one of the largest specimens but the braincase is very low, the maximum width being 41 mm. The sagittal crest is correspondingly high. It bifurcates a short distance anterior to the narrowest part of the cranium.

The American Museum specimens vary in size from those of approximately the same size as the Chicago Museum specimen, with a maximum length of skull of 205 mm., to the smallest, no. 39098, which is 190 mm., the type being also approximately this size. The proportions of the muzzle and basicranium are closely similar with only minor differences. The palate in all instances is somewhat broader, the braincase more inflated. The greatest degree of inflation is found in AMNH no. 11857 with a maximum width of 51 mm. and no. 39098, where it is 48 mm. The greatest width of the cranium in the Chicago Museum specimen is 41 mm. but since no. 39098 is a much smaller skull the cranium is actually much larger proportionally than the difference in millimeters would indicate.

Dentition.—The dentition in all the specimens is closely similar and very distinctive. It differs in many details from that of *Canis*. In fact, it is closer in many respects to that of such a viverrid as *Civetictis*. This is particularly true of the carnassial, the shear of which is oblique and the cusp arrangement quite different from that of *Canis*. The median cusp in *Daphoenus* is a high cone, rounded on its lateral surface, flattened anteriorly. It is well separated from the metastyle which is very low. The internal cusp is on a line with the shear, not set off at an angle sharply from it as in some of the South American canids where this cusp is prominent. It extends very far medially, and is rather posteriorly placed, although not so much so as the same tooth in other genera to be described.

The dental proportions are microdont, the premolar-molar index being 140–150. The trigon of M^1 forms a simple and almost symmetrical triangle. That is one of the important points of distinction from the Recent Canidae, in which the cusps are unequal in size, much more complex and one-sided. The external cusps of M^1 (paracone and metacone) in *D. vetus* are equal and well set off from the margin of the tooth. The internal cusp of the trigon is single and crescent-shaped. In *Canis* it is divided into a hypocone and protocone, with the protocone much the larger and placed at the apex of the triangle. The internal cingulum is very broad in *D. vetus* but not drawn up into a pronounced crest. It swings around the posterior margin of the tooth to give it a subquadrate form. Since the development is almost equal anteriorly and posteriorly there is not the asymmetry of the typical Canidae.

There is little variation in the premolars. P^1 in all specimens is a simple, forward-directed cone without accessory cusps or a pronounced basal cingulum. P^2 is also simple and well spaced from P^1. It is crowded against P^3 which has a small posterior cusp and a well developed basal cingulum. In the series of skulls examined there was also little variation in the molar dentition. M^1 appears more massive in AMNH no. 39098, and M^2 smaller. There is a tendency for the reduction of M^3, which varies from an elongate tooth in the Chicago Museum specimen to a mere nubbin in AMNH no. 39098.

The canine is more variable. In the Chicago Museum specimen the tooth is broad-based, stout, protruding forward and outward. It more closely resembles the same tooth in *Felis tigris* than in *Canis*. In the American Museum specimens the canine is broad-based, but sharper and recurved as in *Canis*. In no. 39098 the tooth is slenderer and the curvature most pronounced.

EXPLANATION OF PLATE 85

FIG. *1*—*Protemnocyon inflatus* Hatcher, USNM 17845. ×0.7. (p. 592)

2, 3—*Daphoenus hartshornianus* (Cope). *2*, USNM 17846. *3*, AMNH 12450, showing short, highly inflated cranium. Both ×0.7. (p. 587)

FIG. 2—*Daphoenus velus* (Leidy), ×0.5. *1*, AMNH 12451, ventral view of skull. *2*, dorsal view. *3*, AMNH 9759, dorsal view.
(p. 580)

The lateral incisors are longer than the median ones and very stout in the one specimen where they are preserved in place (no. 11857). They are separated from the median incisors by a diastema. This appears to have been the case also in specimen no. 12451 but the distortion of the anterior part of the palate makes this less apparent. In specimen no. 38098 the teeth are not as separated from the median ones as in no. 11857.

The lower sectorial is of the same primitive type as the upper, with rounded almost equal cusps. The heel is basined with equal external and internal cusps in no. 39098, with unequal cusps, the external one being higher in the rest of the specimens. In no. 12451 this is the most pronounced and more so on one side than the other. M_3 is present on both sides in all specimens where the lower jaw is complete.

Auditory region.—The auditory region which is very similar in all the specimens is very characteristic and differs markedly from *Canis*. Since an earlier paper by the writer (Hough, 1948) treats it in detail only the more essential features will be described here.

The basioccipital is very broad, the auditory region proper narrow; the basicranium is relatively long, in part due to the great distance between the paroccipital process and the condyles and in part to the length of the paroccipital itself. The auditory region proper is short. In *Canis* the tympanic cavity extends posteriorly almost to the tip of the skull. When the region is covered by the bulla the posterior margin of that structure is in contact with the base of the paroccipital process which is directed almost vertically downward and outward. In small canids with very large bullae the posterior wall of the bulla is closely appressed to the process throughout its length and if the bulla is very large it may project below the tip of the process.

In *Daphoenus* the exoccipital forms almost one-third of the basicranium. The paroccipital process is a flattened, triangular rod, directed backward in a plane parallel to the surface of the basicranium. The bullae are always small when present, but even if they were large they would not be in contact with the paroccipital process. This point is discussed more at length in the comparison, made later in the paper, between a small species of *Daphoenus* and *Pseudocynodictis*.

The promontorium is small and pyriform. The fenestra cochleae faces downward, laterally and posteriorly. The mastoid is well developed and extends laterally as a broad rugose surface not, however, produced into a rod or knob. It is connected with the base of the promontorium by a bony ridge which is pierced by a foramen. The ridge is probably composed of the mastoid process of the periotic and, if a bulla were present, perhaps a portion of the tympanic remaining after its loss. A groove on the mastoid extending from this foramen almost directly laterally across the process forms a third part of the facial canal as described by van der Klaauw (1931). The promontorium is in contact medially with the upturned edge of the basioccipital. At the postero-medial corner there is a large fossa which includes the foramen lacerum posterius and the posterior opening of the carotid canal.

The Chicago Natural History Museum specimen does not have an auditory bulla. A bulla is present in almost all of the American Museum specimens. This may, of course, be due to accidents of preservation. There is, at least the suggestion, however, that either an ossified bulla was not present in the Chicago specimen or was less firmly attached than in the other forms.

When present the bulla is a small inflated ring, placed very anteriorly. A short rounded styliform process extends forward well beyond the postglenoid process. The bulla meets the squamosal anteriorly in close contact and posteriorly is ankylosed with the mastoid process. It crosses the promontorium in such a way as to leave the posterior portion exposed. The general shape and structure of the bulla is closely similar to that of the anterior chamber of the Felinae.

The auditory region in the type, USNM no. 658, is well preserved and the detailed description of it given by Leidy entirely correct in spite of Hatcher's statements to the contrary (Hatcher, 1902). The small ring shaped bulla characteristic of *Daphoenus* is present on the left side and not on the right. It is less inflated, more restricted medially, and more of a simple ring than

in the other specimens described. The auditory meatus is very large and almost round. The bulla does not extend as far forward as in the other specimens. The posterior leg of the tympanic is ankylosed to the mastoid in the usual way. There is a large fossa at the posteromedial corner of the bulla which cuts out a circular area in the basioccipital. This seems to imply the presence of a posterior chamber to the bulla.

There is no doubt of the structure described above being the tympanic bulla as Leidy thought. The promontorium is present above the bulla which crosses it at about the level of the fenestra cochleae. There is no bulla on the other side and a comparison of the promontorium of the two sides leaves no doubt that the bulla is not that structure. It is probable that Hatcher did not examine the type.

Postcranial skeleton.—Earlier writers have pointed out the many feline characters of the skeleton of *Daphoenus* (Scott, 1898, Hatcher, 1902, Peterson, 1910). They compared the skeletal material at hand with that of *Canis*. To a certain extent this obscured the real situation between the two forms because a comparison implies that there is a common basis from which there is more or less deviation. *Daphoenus* and *Canis* have little more in common however than such features as all carnivores have in common. On the other hand, the correspondence to *Felis* is very close. In fact, the only features in which the postcranial skeleton of AMNH no. 11857, the most complete skeleton of *Daphoenus* known, differs from the lynx are certain adaptive characters of the limb girdles and feet.

The atlas is practically identical with that of *Felis*. The edges of the transverse processes are broken in this specimen of *Daphoenus* but it is evident from what remains that they were broad and had essentially the same shape. In the contours of the centrum and the arrangement of the foramina there is no significant difference. The axis is the same general shape but differs in the greater depth of the centrum and height of the spinous process. This may be due to compression. The other vertebrae in the two forms are similar. The spines are the same height and the anticlinal vertebra the tenth as in *Felis*.

The scapula presents some differences. In the lynx it is elongate, with a palette-shaped coracoid border, and a straight glenoid border. There is a very narrow extension of the glenovertebral angle which serves for the attachment of the M. teres major. In *Daphoenus vetus* the coracoid border is straighter, without the curved flare. The glenovertebral angle is produced into a shelf-like process divided from the rest of the lateral surface of the scapula by a sharp ridge which continues as the glenoid border. Since the M. teres major has its origin on this process and lies on the fossa of the medial surface of the glenoid border these features in *Daphoenus* point to a greater development of this muscle, the action of which is to rotate the humerus inward. In the Ursidae the process described is even more pronounced. It would seem from this that *Daphoenus* had a degree of rotation somewhat between that of the more cursorial animals such as the cat and dog, and the plantigrade bears.

The acromion process in the lynx is short, slender, and continues practically in line with the spine of the scapula. The metacromion is well separated from the acromion and is directed toward the glenoid border. In *Daphoenus* the acromion is bent toward the coracoid border almost at right angles to the spine. The metacromion is hardly a separate process. Since it is the point of attachment of the M. levator scapulae ventralis, the action of which is to raise the scapula craniad, one would expect a stronger attachment in the lynx, which is an excellent climber, than in *Daphoenus* which almost certainly was not.

The great scapular notch is not as well developed in *Daphoenus* as in the lynx and the glenoid cavity seems shallower. The development of the coracoid process seems about the same in the two forms.

There is no essential difference in the humerus. In *Daphoenus* the shaft of the bone is perhaps a little more curved and the distal end more expanded. Otherwise, feature for feature, the agreement is very close. The ulna presents a little distinction. The distal end is less triangular in shape and much stouter. In *Canis* this bone is even longer and more tapering than in *Felis*. The styloid process in *Daphoenus* is wider

and longer. It is separated from the head by a wider groove, and the head itself is larger. The olecranon process is about the same in the two forms. The facet for articulation with the radius is broader and longer, indicating greater pronation of the lower arm. The shape of the radius is somewhat more curved, but otherwise the bone is closely similar in all features to that of the recent form. The shaft just above the styliform process, however, has a medial flange which is more pronounced than in *Felis*.

The scapho-lunar does not present any significant differences. The unciform is longer and narrower. The other carpals are closely similar.

The metacarpals also present few differences from those of the lynx. Metacarpals II, III, and IV and V are approximately the same length relatively and absolutely as in the modern form and very little stouter. The only pronounced difference is found in metacarpal I which is long and slender in *Daphoenus* while in the lynx it is very reduced and broad with a strong palmar curvature. This type of difference is, of course, to be expected in a primitive carnivore and is correlated with the less digitigrade gait. The articulation of the metacarpals with each other is such as to show that the spread of the digits was much greater than in living felids.

The pelvis differs from that of the lynx perhaps more than any other bone, although the general shape and proportions are the same. The ilium is much broader and the gluteal cavity deeper and broader. It is bounded inferiorly by a broad low ridge, the lower surface of which forms a part of the narrow concavity running parallel to the edge of the bone. The iliopectineal eminence is very large and rugose. The crest of the ilium is missing, but it must have been longer and broader than that of the lynx. The great sciatic notch is more pronounced, the spine of the ischium much less developed, in fact, hardly discernible. The auricular impression for the articulation of the sacrum is very large. The acetabulum is about as deep as in the lynx but it is placed more obliquely in relation to the horizontal axis of the body. This means of course that the limbs were carried less directly under the body than in *Felis* or *Canis* but had more the position of those of the bear.

The ischium is much longer and straighter than in the lynx, with a very pronounced tuberosity. The pubis is broken so that little comparison can be made.

The femur of *Daphoenus* differs very little from that of *Felis*. The distal end is more expanded, the head larger proportionally, the neck broader. Otherwise the features are closely similar. The tibia also does not present any significant differences.

The astragalus is extremely like that of the lynx. The trochlea in *Daphoenus* is somewhat more oblique in relation to the neck, and less deeply grooved. The head is larger with a much broader and more convex articular surface. This is in accord with the other indications of a semi-plantigrade gait. The distal end of the calcaneum is somewhat broader and the groove for the tendon of Achilles more sharply defined. The facet for articulation with the astragalus is larger, almost hemispherical, and the sustenaculum tali very broad. This allows more play in the ankle joint.

The metatarsals are shorter and broader. They are of the same length in relation to each other as in the lynx, except for metatarsal I. As in the forefoot this digit is relatively long and slender in *Daphoenus*, where in *Felis* it is reduced to a rudiment. The metatarsus is very compact, much more so than the metacarpus and almost as much as in the modern form. The claws are at least partially retractile.

Comparison of the specimen just described with the Carnegie Museum specimen of *D. felinus* and other partial skeletons associated with skulls of *D. vetus* shows that there is very little variation in the respective parts, in fact, in any essential features there is none at all.

This lack of variation is in contrast with the typical Canidae of the John Day where, even within one genus, *Mesocyon*, there is evidence of a wide range of adaptive differences in the limbs. In some species, *Mesocyon hortilurosae*, for example, there is an approach to the recent Canidae so close that the entepicondylar foramen is lost; in others the structure of the limbs approached that of the wolverine; in the related *Enhydrocyon* there are hyaena-like characters. The species of *Nothocyon* vary also from the more civet like *Pseudocynodictis gregarius* to the typically canid *Nothocyon geismanianus*.

FIG. 3—*1, 2, Daphoenus vetus* (Leidy), dorsal and ventral views of skull, AMNH 39098, ×0.5. *3, 4, Daphoenus hartshornianus* (Cope), dorsal and ventral views of skull, AMNH 12450, ×0.5.
(p. 587)

Daphoenus felinus Scott: Carnegie Museum specimen no. 492, a skull and virtually complete skeleton, was originally described by Hatcher who referred it to *D. felinus* Scott, the type of which is a lower jaw and almost complete skeleton. Scott later (1937) considered *D. felinus* specifically identical with *D. vetus*. Examination of the Carnegie Museum specimen, however, shows many minor differences and while *D. felinus* is probably not a different species it seems to be a good subspecies. Since *D. vetus* is the type of the genus *Daphoenus* it is probably not sound taxonomic practise to use parts of *D. felinus*, which is not at all typical, in the generic description of *Daphoenus*.

D. vetus felinus is larger than the smaller forms of *D. vetus vetus* but it is not larger than the Chicago Museum specimen described previously. Scott suggested that the differences in size might be due to sex, the larger form being male. *D. vetus felinus*, however, is from Sioux Co., Nebraska and specimens are known of *D. vetus vetus* from several localities in South Dakota and Wyoming with no association with any smaller form. This may be due to accidents of sampling, of course, but it does not afford any proof of sexual distinction.

Moreover, the dentition differs in a way which could hardly be due to sex. P^2 in *D. vetus vetus* is crowded against P^3. In *D. vetus felinus* it is separated by a diastema. The carnassial is not only larger in the latter form but it is a different shape. A more pronounced metastyle is present and the antero-internal cusp is set off at an angle from the shearing surface of the tooth in a way resembling certain South American canids in which this cusp is prominent. This was noted by Hatcher. The tooth is still more triangular than that of any recent canid, but much less so than *D. vetus*. M^1 is a much more elongate tooth, the external-internal diameter exceeding by a third the anteroposterior diameter. The external cusps of the trigon are unequal, the anterior one being larger. The internal cusp is situated much more medially. The cingulum is but little developed anteriorly, but more developed posteriorly than in *D. vetus* in a symmetrical way, without the typical flare of the Canidae. This gives the tooth a quadrate inner margin. M^2 is broader and better developed, but M^3 on the contrary is smaller, and the anteroposterior length greatly exceeds the width. It is situated parallel to the curved hinder margin of the palate.

The canine is essentially the same in both forms and the other teeth are closely similar. The auditory region also does not offer any significant points of distinction.

Walker Museum skull no. 477 which has a well preserved basicranial region but very badly weathered dentition agrees in size and proportions with the Carnegie Museum specimen. The canine is of the *Daphoenus* type, broad based and straight edged, protruding outward and forward; the carnassial is similar to that described for the Carnegie specimen and the molar has the cingulum developed as described above. The other teeth are too obliterated for comparison.

DAPHOENUS HARTSHORNIANUS (Cope)
Plate 85, figures 2, 3,
Text figures 3.3, 3.4

Canis hartshornianus COPE, 1873, U. S. Geol. Survey of the Terrs., Adv. sheets, 7th Ann. Rept., p. 9.

Specific characters.—Size that of a small coyote. Skull maximum length 160 mm. to 184 mm. Palate relatively wide, muzzle narrowing abruptly in front of orbits. Basicranium shorter than in *D. vetus*. Braincase highly inflated. Sagittal crest low. Canines slender, recurved, oval in cross section. Molars triangular with asymmetrical cingula. Carnassial relatively large, molar index 131. M^3 reduced or absent. Heel of lower sectorial basined.

Type.—American Museum of Natural History no. 6811.

Locality.—Cedar Creek, Logan Co., Colorado.

Horizon.—Orellan.

Specimens examined.—AMNH no. 6811, Cedar Creek, Logan Co., Colo.; AMNH no. 9757, no. 12450 Corral Draw, Big Badlands, S. D.; HSNM no. 17846, Niobrara Co., Wyo.

Description of specimens.—This species was described by Cope under the name of *Amphicyon hartshornianus*. The original specimen was a portion of a lower jaw from eastern Colorado to which Cope added later (1884) a description of a second specimen,

a palate with well preserved teeth, from the same locality. Leidy had previously (1869) given accounts and figures of two other incomplete skulls under the name *Amphicyon vetus*. Scott (1898) added descriptions of the posterior part of the skull and basicranial region.

Two of the American Museum specimens are exceptionally complete and well preserved skulls. The other, no. 6811, is Cope's type. American Museum no. 9757 is a very perfect skull, with unworn and practically complete dentition. Only the left canine and first premolar are broken. The auditory region is intact with a small bulla present on the right side. The size is about that of *Canis latrans*. The proportions are characteristically daphoenid; short muzzle and palate, long cranium and basicranium. The muzzle is shorter and tapers more sharply than that of *D. vetus*. The posterior part of the skull and the basicranial region of course cannot be compared to the type. In comparison with *D. vetus* the cranium is much more highly inflated and the sagittal crest lower. The postorbital processes are more pronounced. AMNH no. 12450 has an even larger cranium. The skull itself is slightly smaller but the proportions are the same as those of the type.

Dentition.—The dentition is very characteristic and distinct from that of such a typical specimen of *D. vetus* as Chicago Museum specimen no. 12021. The canine which in the latter is short, stout and straight, in *D. hartshornianus* is slender, compressed and curved. The carnassial is thinner, with a high median cusp and straight internal shearing surface. The molars are relatively small. The outer cusps of the trigon of M^1 are high and equal in size. There is little division between them. The internal cusp in no. 6811 is worn almost level but was situated close to the two outer cusps. The cingulum is broad and produced into a low cusp back some distance from the internal margin. The cingulum does not extend around the anterior portion of the tooth and is wider on the posterior side of the apex of the trigon. This gives the tooth an asymmetry approximating that of *Canis*. This is even more pronounced in M^2 which is quite small but completely formed. M^3 is a nubbin placed in the edge of the palate. There is only one root.

The dentition of AMNH no. 9757 is closely similar to that of the type and there is no doubt of the specific identity. The canine is somewhat broader and shorter, P^1 is larger, P^4 less compressed with more rounded cusps. M^1 and M^2 are both slightly larger than in the type.

AMNH no. 12450 differs from the type and from no. 9757 in minor ways. The canines are long, slender and recurved much like those of the type. The molars are larger with a better development of the internal cusp of the trigon. This cusp is more central in position and the trigon itself is broader. There are two cuspules on either side of the apical cusp. The cingulum is very broad and extends somewhat anteriorly as well as posteriorly. This gives the internal margin of the tooth a more rectangular outline than in the type. In this respect and in the size of the molars proportionally to the carnassial, this specimen intergrades with *D. vetus* no. 39098.

Auditory region.—The auditory region is exceptionally well preserved in both AMNH no. 9757 and no. 12450. It is very similar in all details with that of *D. vetus* except for being relatively shorter and broader. The bullae which are present on both sides in one specimen and on the right side in the other are small, ring-shaped and highly inflated. The medial anterior corner is produced into a short styliform process which extends far forward beyond the level of the postglenoid process. The external auditory meatus is a very large circular opening without a tubular extension. The floor of the meatus is formed of the squamosal and extends some distance laterally of the auditory opening. The anterior leg of the tympanic meets the squamosal in close contact at the base of the postglenoid process. The posterior leg is ankylosed with the mastoid process. The bulla crosses the promontorium about midway, leaving the posterior portion exposed.

Postcranial skeleton.—The skeletal material associated with AMNH no. 1287—a lower jaw and portions of the upper dentition—is fragmentary but has portions of all of the important elements. The likeness to the lynx in this smaller form is even more striking.

The specimen is about the size of the type, no. 6811 and has similar dental characteris-

tics. The bones are the size of those of a lynx, specimen no. 2434 from the comparative anatomy collection of the American Museum, used for comparison.

The greater approach to *Felis* is seen particularly in the limb girdles. The acetabulum, for example, which is almost entirely intact, although portions of the pubis are missing, agrees in every detail and lacks the obliquity which characterized the larger specimen of *D. vetus*. This would seem to indicate that the limbs were carried more directly under the body.

The ulna is also more like that of the lynx. It is more triangular in shape, the shaft tapering to a very narrow distal end as in *Felis*. The head of the femur is smaller and the neck narrower.

The same correspondence occurs in all comparable parts, i.e. the astragalus, calcaneum and other tarsal elements. The metatarsals and metacarpals are unfortunately unknown so it is impossible to say if this individual was more digitigrade. Scott's figures (1898, plate XX, 21a, 22) would seem to indicate that this was the case.

Relationships.—Cope distinguished *D. hartshornianus* Cope from *D. vetus* by (1) the much smaller tubercular molars and (2) the basined heel of the lower sectorial. Scott (1937) gives as the specific difference the smaller size and the smaller molar dentition. Hatcher noted the inflation of the braincase, and suggested that *D. hartshornianus* and *Protemnocyon inflatus* are specifically identical.

In the type, no. 6811, and in no. 9757 M^1 and M^2 are small proportionally to the carnassial. The molar index is 131. In no. 12450 the molars are larger as well as more quadrate. The molar index is 146. The specimens of *D. vetus* range from 130 in the American Museum specimens to 150 in Chicago Museum no. P 12021. There is thus an intergradation in molar size and the character cannot be used to separate the two species. The size of the skull as a whole is also a difficult criterion to apply because, while the American Museum specimens certainly referable to *D. hartshornianus* are smaller than the *D. vetus* specimens, Princeton Museum no. 13450 with a cranial width of 60 mm. is larger than AMNH no 38098, the maximum width of the cranium of which is only 46 mm.

The two best distinctions seem to be the inflation of the braincase, and the basined character of the heel of the lower sectorial, taken in combination. The relatively large size of the cranium in proportion to the skull is very pronounced and in the typical specimens is combined with a characteristic contour of the muzzle and palate, a slender lower jaw and basined heel to the lower sectorial. *Protemnocyon inflatus*, to be described later, has a large cranium but the shape of the anterior part of the skull is different, the dentition more compressed, and the heel of the lower sectorial strongly trenchant. It is an interesting point that the absolute size of the cranium varies only a few millimeters. The greater relative size seems to be due to the fact that the absolute size remains the same, but as the animal grows larger the relative size decreases proportionally. It seems best to retain *D. hartshornianus* as a separate species, however, in spite of the large amount of intergradation because the extremes are so different. No. 6811 and no. 9757 which are the most typical *D. hartshornianus* specimens from the American Museum collections come from Logan Co., Colorado. The original specimens of Leidy and Cope are all from eastern Colorado. The specimen with the most quadrate and largest molars comes from South Dakota. It is possible, therefore, that we are dealing with a geographic chain of subspecies, the extremes of which are different enough to simulate different genera and yet which intergrade from group to group. Numerous examples of this type of speciation are known among present day mammal populations. A larger number of *Daphoenus* specimens, of course, from more localities are needed to solve the problem adequately.

DAPHOENUS MINIMUS Hough, n. sp.
Plate 86, figures 3, 4

Specific characters.—Size that of a pine marten. Maximum size approximately 100 mm. Braincase large, muzzle short.

Type.—American Museum no. 39099.

Locality and horizon.—Scenic. S. D., Orellan.

Discussion.—The taxonomy of the small canids of the American Oligocene is extraordinarily confused. The first description of a small carnivore from the "Mauvaises Terres of White River" was by Leidy who named the species *gracilis*.

Amphicyon gracilis. This name, however, was preoccupied by Pomel's *A. gracilis*, an entirely different species. In 1871 Marsh described the anterior part of a lower jaw as *Amphicyon angustidens*. Since the specimen consists of only the first three premolars and the canine it is almost indeterminable except as to size. Cope (1873) described a series of lower jaws of small canids "about the size of a red fox" and named them *Canis gregarius*. Later (1884) he added more specimens from the John Day, which included complete skulls and referred Leidy's specimen, which now had no valid name, to the new species, and established a second species of larger size based on the anterior part of a skull and jaws, American Museum no. 1384. (The type is a very fragmentary lower jaw with only P_1 and M_4 present.) Scott (1898) adopted the European name *Cynodictis* for all the small canids of both the American and European Oligocene.

Matthew (1899) referred *Cynodictis angustidens* and *C. gracilis* to *C. lippicottianus* (cope), the larger species referred to above. Schlosser (1902) proved the American form to be distinct from the European *Cynodictis* and named the American genus *Pseudocynodictis*. Scott (1936) included both *angustidens* and *lippicottianus* in *Pseudocynodictis gregarius*. The name *angustidens*, however, antedates *lippicottianus* since Marsh's description was written in 1871, Cope's in 1873. If the two are synonomous *angustidens* is the valid name. Moreover, it also antedates *gregarius*. The writer believes, however, that while *angustidens* and *lippicottianus* are the same species, they are distinct from *P. gregarius*. *P. gregarius* is not only smaller but differently proportioned and is known from a large number of specimens all with much the same characters.

The problem is complicated still further by the fact that in all of these nomenclatural changes it was assumed that all of the small White River canids belonged to a single genus. A recent examination of two specimens in the American Museum seems to show almost conclusively that there were actually two distinct genera.

The specimens in question are skulls of small carnivores described earlier in the paper, collected together from the *Oreodon* beds of Scenic, South Dakota. One is associated with jaws and limb bones, and is clearly *Pseudocynodictis gregarius*. The other found with it is a daphoenid and quite different in proportions of the skull and details of the auditory region from *Pseudocynodictis*. It seems necessary therefore to make it the type of a new species of *Daphoenus*. Since it differs from D. *hartshornianus* and *D. vetus* only in size and characters correlated with size, the name *Daphoenus minimus* is proposed. It is possible that there are other specimens referred to *Pseudocynodictis* which are, in fact, daphoenids.

Description of specimens.—The skull is a little larger than that of *Pseudocynodictis* and the proportions quite different. The anterior part of the muzzle is broken, but the muzzle was clearly shorter than that of *Pseudocynodictis*. The basicranial region on the other hand, and the cranium are relatively longer. The braincase is as large as that of *Pseudocynodictis* but of somewhat different contours. The specimen is flattened somewhat antero-posteriorly so that its shape cannot be accurately described but it would seem that the cranium was lower and broader. The sagittal crest is low. The bifurcation of the crest takes place slightly posterior of the narrowest part of the cranium, which is just behind the postorbital process. In *Pseudocynodictis* this bifurcation commences at the point of greatest expansion of the cranium, about two thirds of the distance antero-posteriorly of the skull. The ridges are close together for some millimeters and separate gradually. In all of the *Daphoenus* group the bifurcation is abrupt.

Dentition.—The dentition of specimen no. 39098 also has many typically daphoenid features, which are in contrast with those of *Pseudocynodictis*. The anterior premolars of the latter, for example, are complex. Even P^1 has a small posterior cusp. Similar cusps are present on P^2 and P^3 which also has a small cingular cuspule. There are no basal cingula on P^1 and P^2. In *D. minimus* the first premolar is missing on both sides, but P^2 is a simple cone with a pronounced basal cingulum but no accessory cusps.

The shearing edge of the carnassial in *Pseudocynodictis* parallels the outer edge of the palate. The antero-internal cusp is rounded and distinct. It is situated in advance of the median cusp of the same tooth.

There is a slight parastyle. The metastyle is low and incompletely separated from the median cusp. In *D. minimus* the carnassial is placed much more obliquely in the tooth row. The antero-internal cusp is crescent-shaped and not well separated from the body of the tooth. The anterior margin of this cusp lies posteriorly of the anterior margin of the tooth. There is no parastyle. The median cusp is lower, more rounded and has a characteristic postero-internal slant in contrast with the vertical alignment of the same cusp in *Pseudocynodictis*.

M^1 differs markedly in the two forms. In *Pseudocynodictis* the external cusps are subequal, the anterior one being higher. These cusps are situated close to the margin of the tooth. The external cingulum is very weak posteriorly; anteriorly it is produced into a pronounced cuspule. The internal cusp is also situated close to the internal margin of the tooth, making the trigon very long. There is no anterior internal cingulum. Posteriorly this structure forms a high crest which gives the tooth the typical canid swing posteriorly. M^2 is a miniature of M^1. There is no M^3.

In *D. minimus* the external cusps are almost equal in height and set back from the margin of the tooth which is formed by a cingulum extending the antero-posterior length of the tooth. The anterior corner is produced into a cusp in *D. minimus*, but this cusp is smaller. The internal cusp is situated very near the external cusps, almost touching them in fact, making the trigon very short. The cingulum surrounds the internal margin of the tooth and the crest is median rather than posterior in position. M^2 is a miniature of M^1. The hinder margin of the tooth row is broken. There may have been an M^3, but if so it was very small.

Basicranial region.—The basicranial region has the characteristics common to all of the daphoenid genera. The basioccipital is broad. The lateral margins curve downward to form a close contact with the promontorium. The auditory cavity proper is relatively narrow. The promontorium, the typical pyriform shape of which is somewhat obscured by flattening in this specimen, occupies almost all of the cavity. There is no bulla. The roof of the meatus is a broad arch formed by the squamosal. The mastoid is prominent for so small a skull. A process from the mastoid bridges the facial canal, coming in contact with the mastoid just opposite the fenestra cochleae. This fenestra, which is relatively large, faces laterally and posteriorly. The paroccipital is produced into a narrow triangle which projects backward and only slightly downward and medially. This type of process, which is found in all of the daphoenid specimens differs characteristically from that of *Pseudocynodictis*, where it projects almost vertically downward. Even if a large bulla were present in *Daphoenus* the base of the paroccipital process would not embrace the posterior part of the bulla as it does in the typical Canidae. In these, the whole exoccipital is cup-shaped and fits closely around the roof and hinder margin of the bulla. In *Daphoenus* it is horizontal extending as a flat sheet to the base of the promontorium. The condition in *Daphoenus* is much more like that of the bears than either the Canidae or Felidae.

PROAMPHICYON NEBRASKENSIS Hatcher
Plate 84, figures 1, 2

Proamphicyon nebraskensis HATCHER, 1902, Carnegie Mus. Mem., vol. 1.

Specific characters.—Skull elongate; sagittal crest high; braincase small; premolars reduced in size and well spaced; carnassial with rounded median cusp, and antero-internal cusp relatively posterior in position.

Type.—CM no. 491.

Locality.—Bad Land Creek, Sioux Co., Nebraska. Chadronian and Orellan.

Specimens examined.—CM no. 491 (type), Bad Land Creek, Sioux Co., Neb., Walker Museum no. 1426, Hat Creek Basin, Sioux Co., Neb.

Description of specimens.—The type of *Proamphicyon* is *P. nebraskensis* Hatcher, Carnegie Museum no. 491, a very incomplete skull lacking the zygomata, posterior portion of the sagittal crest, part of the basicranial region, I^3 and M^3. It is compressed laterally; the teeth are worn and the canines rather more broken than appears in Hatcher's figure. A specimen in the U. S. National Museum, however, is clearly referable to the genus and is much more complete. The only teeth missing are the

incisors of the left side, P^1 on the left side and P^3 on the right side. A minute alveolus for M^3 may have been broken off the right side. There seems to have been no alveolus for this tooth on the left side.

The pterygoids are broken and the anterior part of the skull slightly compressed. The remainder of the skull including the auditory region is in almost perfect condition. The general aspect is that of *D. vetus*, although somewhat smaller and more slender than the Chicago Museum specimen. The braincase and sagittal crest, which bifurcates anteriorly of the sharp constriction of the cranium, make the resemblance very close. The muzzle, however, is longer and narrower and the characteristic flare caused by a decided constriction anterior to P^3 and an outward curve just posterior to the base of the canine, together with the narrowness of the palate and the length of the canines give it the *Amphicyon*-like appearance on which the name is based.

Walker Museum no. 1426 is a very perfect right half of a skull mounted on a plaster slab. It agrees in all the above features with the type and the National Museum specimen, and the auditory region which is perfectly preserved is typically daphoenid.

Chicago Museum no. P 12140 is a fragment of upper dentition probably belonging to this species and interesting because it comes from the Chadron.

Dentition.—The canines are especially distinctive. They are one-third longer than those of *Daphoenus*, narrower based, slender with cutting edges as described by Hatcher. The tips are recurved in the manner of *Canis* although the teeth are much longer. P^1 is smaller than in either *D. felinus* or *Protemnocyon* and more widely spaced from P^3. P^2 has no accessory cusps and no cingulum; P^3 has a very slight suggestion of a posterior cuspule and a slight cingulum. The carnassial is very distinctive. The shearing surface is not only more oblique and the antero-internal cusp more separated from the rest of the tooth but this cusp is also more posteriorly located. A line drawn medially from the anterior point of the external border of the tooth will not come within 3 mm. of the anterior margin of the internal cusp. In *Daphoenus vetus* such a line barely misses the margin of this cusp and in the Miocene *Cynodesmus* and all of the recent Canidae the internal cusp is well in advance of the anterior margin of the tooth. These characters are much more primitive, in the sense of being nearer *Miacis*, than the condition in *Daphoenus* and it is interesting in this connection to find that the dental fragment mentioned above which has this type of carnassial is from the Chadron and thus earlier than any known upper dentition of a daphoenid.

Relationships.—Scott considered that the differences between *Daphoenus* and *Proamphicyon* were not sufficient for generic distinction. This might seem to be the case if only Hatcher's type were known. The essential features are repeated, however, in the three specimens here described and the dental fragment appears referable to the genus. The carnassial is very distinctive and in connection with the length and characters of the canine and the proportions of the muzzle produce a type, the definiteness of which seems to warrant generic distinction. In modern carnivores the length and shape of the canine are uniform throughout whole families. Much smaller differences in the proportions of the carnassial to the molar dentition, and shape of the carnassial are used as a basis for the various genera of South American Canidae. The name *Proamphicyon* is, of course, unfortunate, because as will be shown later, the genus has no direct relationship with *Amphicyon*.

PROTEMNOCYON INFLATUS Hatcher

Plate 85, figure 1; Plate 86, figures 1, 2

Protemnocyon inflatus HATCHER, 1902, Mem. Carnegie Mus., vol. 1, no. 2, p. 65.

Specific characters.—Temporal constriction anterior to the union of the superciliary ridges. Frontal broad, gently concave medially but convex laterally, indicating the presence of well developed frontal sinuses. Inferior margin of the mandible nearly straight. M^3 reduced or absent. P 1/1, 2/2, 3/3/4 large with broad heels.

Type.—CM no. 552.

Locality and horizon.—Bad Lands, Sioux Co., Nebraska, Orellan.

Description of specimens.—The type of *Protemnocyon inflatus* Hatcher, CM no. 552, is a very incomplete skull and lower jaw with somewhat worn dentition. There are a

few skeletal elements, two articulated vertebrae and a femur. The skull is much smaller than that of *D. felinus* and of somewhat different proportions. The muzzle is shorter and tapers more abruptly, the palate is broader, the basicranial region proportionally shorter and broader. The sagittal crest bifurcates almost at the point of the constriction of the cranium. The latter is much more inflated than that of *Daphoenus*, giving the skull the appearance, as Scott pointed out, of an enlarged *Pseudocynodictis*. The sagittal crest is correspondingly much lower.

The National Museum specimens consist of an upper and lower jaw with exceptionally well preserved dentition, and a skull with somewhat broken teeth. The skull is smaller than the type and of more slender proportions. The relative inflation of the braincase is greater.

Dentition.—Both canines are broken in the type but seem to have been broad-based with rounded oval cross section. The tips are broken in the USNM specimen no. 17844, but the teeth were clearly of the same type as in the Chicago Museum specimen of *Daphoenus vetus*, straight and stout. The rest of the dentition is similar in all of the specimens.

P^1 is a simple cone with a bare suggestion of a cingulum. It is widely spaced from P^2 which is also a simple cone. There is a diastema between it and P^3 which is without accessory cusps. P^3 is placed somewhat obliquely in the tooth row and crowded up against P^4. This tooth has an oblique shear and a prominent internal cusp. It differs proportionally in size from that of *Daphoenus*. The molar index of *Daphoenus* is 150, that of *Protemnocyon* 102, almost within the range of *Canis* (70—100), M^1 is more triangular than in *Daphoenus* and smaller proportionally. It is elongate with little development of the cingulum. M^2 differs in the same way, being subquadrate in *D. felinus*, triangular in *Protemnocyon*. The size of M^3 is similar to that of some specimens of *Daphoenus*. In *Protemnocyon* it was evidently very small and nonfunctional.

The lower dentition has been described in detail by Hatcher. The principal features are: P_1 is a compressed cone directed forward and separated by a diastema from P_2. P_2 and P_3 have two roots but no accessory cusps. They are slightly separated. The cingulum is not well developed but there is a faint cingular cuspule at the posterior edge of the tooth. P_4 has a prominent posterior cusp which is, however, low and incompletely separated from the median cone. All of the premolars are compressed laterally. The inferior sectorial is very worn so that the character of the heel, which Hatcher thought to be trenchant, is not clear. This information is supplied by USNM no. 17844 where the trenchant character of the heel is very marked. There is a single median cusp with no trace of any other.

Auditory region.—The auditory region is well preserved in the Carnegie Museum specimen and is of the daphoenid type. The promontorium is somewhat larger in the USNM specimens and the paroccipital process somewhat broader and blunter. These specimens are larger than the type, however, and these differences may be correlated with the increase in size. There are only fragments of the bulla preserved in the type and no bulla at all in the USNM specimens. From the fragment, however, and the impressions on the surrounding elements of the auditory region in the type and other specimens it would seem that the bulla, although small in comparison with the typical Canidae, was larger than that of *D. vetus*. It is very anteriorly placed, the anterolateral margin extending to a point on a level with the posterior margin of the postglenoid anterior to the fenestra cochleae. The general shape was probably similar to that of *Paradaphoenus* which also agrees with *Protemnocyon* in the relatively great inflation of the braincase.

The bulla and the postglenoid processes are not in contact but widely separated because of the length of the roof of the auditory meatus. This extends laterally in such a way that a large portion of the squamosal is visible from the ventral view of the skull.

Medially the bulla is in contact with the basioccipital. In the type it apparently cut out a circular notch in this bone. This feature is shown on both sides in the type but not in any other specimens. The posterior leg of the tympanic meets the post-tympanic

to form a bridge over the facial canal. The latter becomes entirely enclosed in bone to form the foramen stylomastoideum definitivum which is bounded medially by the tympanic and the tympano-hyal and laterally and posteriorly by the mastoid.

The mastoid process is less developed than in *Daphoenus vetus* and does not form a distinct process. The paroccipital is flattened in all specimens, tapers to a sharp triangular process which is directed entirely backwards with a slight medial curve. The mastoid and paroccipital are almost continuous without the pronounced separation found in some specimens of *Daphoenus vetus*.

Relationships.—Hatcher (1902) suggested that *D. hartshornianus* and *Protemnocyon inflatus* were specifically identical because of the agreement in size and inflation of the braincase. Scott (1937) states as a reason for the distinction of *D. hartshornianus* the proportionally much greater brain capacity of *Protemnocyon* which varies, however, from a minimum capacity not much above that of some of the larger brained *D. vetus*, such as AMNH no. 11857 to a maximum closely agreeing with the *D. hartshornianus* group.

There are other differences which distinguish *Protemnocyon* from *Daphoenus*. The cranium differs in shape. It is somewhat more inflated anteriorly and the maximum width is more dorsal. The sagittal crest is low but the occipital crest relatively high.

The dentition differs in many minor details. The canine is broad-based and round in section instead of compressed and slender as in *D. hartshornianus*. The shear of the carnassial is more nearly parallel with the margin of the palate. The antero-internal cusp is less prominent. M^1 is larger proportionally, and more elongate. The internal cingulum is very symmetrical and forms a higher crest. M^2 is larger. M^3 seems to have two roots, at least in some specimens. Most important of all, the heel of the lower sectorial is trenchant with a high median cusp. This is not a variation of a condition found in any of the *Daphoenus* species. In these even if the talonid is semi-trenchant the development has taken place by the enlargement of the external cusp. In *Protemnocyon* the structure of the heel is like that of the living *Cyon*.

In view of these differences it seems best to retain *Protemnocyon* as a distinct genus. Hatcher also regarded it as ancestral to *Temnocyon coryphaeus*. This species, however, is now included in the genus *Mesocyon*, and the heel of the carnassial is basined. *Temnocyon*, which is a cyonine type, comprises only the species *T. altigenis* and *T. ferox*. In the former the basicranium and skeleton are unknown. In *T. ferox* these parts have the typical canid specializations. The resemblance of the dentition of *Protemnocyon* to these species must be looked upon, therefore, as another example of parallel adaptation.

DAPHOENOCYON Hough, n. gen
Plate 87, figures 1, 2

Definition.—A brachycephalic, short faced carnivore about the size of a large coyote but very differently proportioned. Frontal sinuses prominent, giving the upper profile of the skull something the appearance of that of a domestic dog. Basicranial region very short in comparison with other daphoenid genera. Auditory region short and narrow. Promontorium large. Mastoid produced into a rugose knob projecting downward. Facial nerve apparently leaving the skull through a groove posterior to the mastoid process.

Type species: *D. dodgei* Scott, 1898.

Specific characters.—Lower jaw exceptionally short, maximum length 51 mm. Premolars crowded. P_2 and P_3 as well as P_4 with accessory cusps. M_1 much more primitive with anterior cusp (protoconid) more rounded than in other genera; metaconid also higher and more rounded, talonid with high median cusp.

Remarks.—The only recognized species of *Daphoenus* from the Chadron has long been *Daphoenus dodgei* of which only lower jaws are known. An upper dentition also from the Chadron is described earlier in the paper but since this is not associated with a lower jaw it is not definitely referable to *D. dodgei*. Scott, in describing this species in his White River monograph points out the primitive nature of the lower dentition and its distinction from the other daphoenid genera and suggests that if more complete material were recovered a change in genus might be necessary. The specimens on which *Daphoenocyon* is based are from the Brule,

the one, collected by Mr. Pearce of the U. S. National Museum in 1942 from Niobrara Co., Wyoming, the other from Sioux Co., Nebraska. The lower dentition of the specimens in question checks almost exactly with that of *D. dodgei* so that no features on which a specific distinction could be based are ascertainable. For this reason *dodgei* is used as the type of the genus, although it is probable that when a complete skull is found from the Chadron, the Brule material will prove to be a distinct species.

Description of specimens.—USNM no. 17847. This specimen consists of a skull and jaws which are interlocked, a number of vertebrae, ribs and an articulated pelvis, a humerus, an ulna and some foot bones.

The skull is remarkable both for cranial and facial shortening, paralleling in this respect *Enhydrocyon* of the John Day, with which it also agrees closely in size. The dentition, auditory region and postcranial skeleton, however, are entirely different.

The shortness of the muzzle is made more pronounced by the prominence of the frontal area which gives the upper profile of the skull very much the appearance of a large domestic dog. The braincase, however, although rounded is low and the sagittal crest relatively high, especially posteriorly. The occipital crest is even more pronounced.

The lower jaw is deep vertically and thick. The coronoid process is very wide and truncated. The lower margin of the jaw is sinuous with a pronounced curve just below the angle of the jaw.

The extreme posterior part of the basicranium is broken so it is impossible to tell from this specimen the exact length of the region, but it was certainly unusually short, due rather to the shortness of the distance from the postglenoid process to the paroccipital than the distance from the latter to the condyles which is long as in all daphoenids. The auditory cavity is narrow, the basioccipital broad—both typical features. The postglenoid process is widely separated from the mastoid so that the roof of the meatus forms a broad, shallow arch. The mastoid process is very prominent and forms a rugose knob directed slightly posteriorly as well as downward.

The promontorium is exceptionally large, filling the auditory cavity. The fenestra cochleae is directed ventrally and only slightly posterolaterally. The true tympanic cavity is narrow; the epitympanic recess situated well under the roof of the meatus. The facial canal is short and very deep. The posterolateral corner of the promontorium is connected with the mastoid but this does not form a bridge over the facial canal. The facial nerve evidently did not traverse the mastoid but left the skull directly behind the mastoid process. There is a small concavity on the mastoid just lateral of the postero-external corner of the promontorium which probably lodged the tympano-hyal.

A portion of the bulla is present on one side. It is very anterior in position, closely appressed to the base of the postglenoid process.

The upper canine is the only part of the dentition which is clearly visible in this specimen. It is a broad tusk-like tooth similar to that in the Chicago Museum specimen of *D. vetus*. It protrudes forward and outward with very little curvature.

Walker Museum no. 1456. This specimen consists of an articulated skull and jaws with the latter opened in such a way, however, that the teeth are readily observable. The skull is compressed laterally which results in some distortion. It is clear that it is the same size and proportions as the USNM specimen, and with the same prominent frontal area. The dental measurements correspond closely with the Princeton Museum specimen of *D. dodgei*, no. 13601. Scott states that this specimen has the teeth crowded in such a way that the total premolar-molar length is only 39 mm. This is not true of these specimens where the total length is 51 mm., although the measurements of the individual teeth are the same.

The basicranial region is incomplete on the right side in much the same way as that of USNM no. 17847, but the left side is intact except for a small portion of the paroccipital. The distance from the postglenoid processes to the posterior margin of the paroccipital is exceptionally short in comparison with that of *Daphoenus* although the basicranial measurements are the same because of the greater length from the margin of the paroccipital to the condyle. The basicranium is also unusually narrow. In consequence the auditory region is short ab-

solutely and relatively. The promontorium is usually large. It is also more rounded in shape, curving gently and almost equally in all directions. There is a slight elongation and flattening of the antero-medial portion but this is not nearly so marked as in the *D. vetus* specimens. The shape of the promontorium compares in fact more with that of *Canis*. The fenestra cochleae is large and round and faces laterally and posteriorly.

The mastoid is similar to that of *Proamphicyon* but larger and with a downwardly projecting process at its anterior margin. This forms the posterior wall of the meatus. The facial canal in this specimen as in the USNM specimen could not have crossed the mastoid. Instead there is a groove just posterior of the mastoid process which must have formed the third part of the facial canal.

The shortness of the basicranium causes the exoccipital also to be much shorter than in the other daphoenids. A triangular piece is broken from the posterior margin so that the exact shape of the paroccipital process is difficult to make out, but it was apparently not well separated from the mastoid and projected very little posteriorly.

Dentition.—Of the upper dentition only M^1 and M^2 are preserved and observable on the right side and P^2, P^3 and M^2 on the left. P^1 is a rounded forwardly directed cone with a strong cingulum; P^2 is two-rooted with a blunt median cone and a small posterior cusp; P^3 has a strong central rounded cusp and a small but pronounced posterior cusp. The cingulum is well developed and produced into a cusp posteriorly. The carnassial was not observable. The premolars are crowded against each other and are rounded with low cusps as compared with such a genus as *Protemnocyon*.

M^1 and M^2 are both triangular in shape and very symmetrical. The cusps which form the trigonid are regularly spaced and form a broad triangle well set in from the external margin of the tooth. The internal cusp (protocone) which forms the apex of the triangle is low and near the internal margin of the tooth. The trigonid is almost exactly balanced by the cingulum which is broadly developed anteriorly but with little posterior extension. The general aspect of the tooth is like that of *Miacis*, except for the larger size. M^2 is a very small tooth and placed in the angle of the jaw. It is elongate, however, and a miniature of M^1. M^3 is apparently absent.

The lower dentition is perfectly preserved on both sides except for the tip of the canine. These teeth are long and more curved than the upper canines. The surface is finely serrate. P_1 is a small cone directed slightly forward. There is a trace of a posterior cingulum. P_2 is large with a pronounced posterior cingulum and a small posterior cusp. P_3 is almost the same size as P_2, with a strong posterior cingulum and well-developed posterior cusp. P_4 is larger with a larger posterior cusp and a more pronounced cingulum. All of the lower premolars have rounded blunt cusps. M_1 has an exceptionally high trigon, the median cusp of which is rounded and very prominent. The anterior and internal cusps are almost as high as the median one. The heel is low and although worn almost certainly consisted of a single median cusp. M_2 is small and M_3 possibly absent on one side.

The premolars are all in contact with each other. P_2 overlaps slightly on P_3 and is set in an angle to the axis of the jaw. P_4 is crowded against M_1.

Postcranial skeleton.—Only the proximal part of the scapula is preserved. The neck is broader than that of *Felis* but the glenoid cavity agrees closely with that of the lynx both in general shape and in the configuration of the coracoid process. Both in *Canis* and *Ursus* this process lacks the hook-like projection which is characteristic of *Felis* and found also in *Daphoenocyon*. The spine is very prominent and inclined toward the

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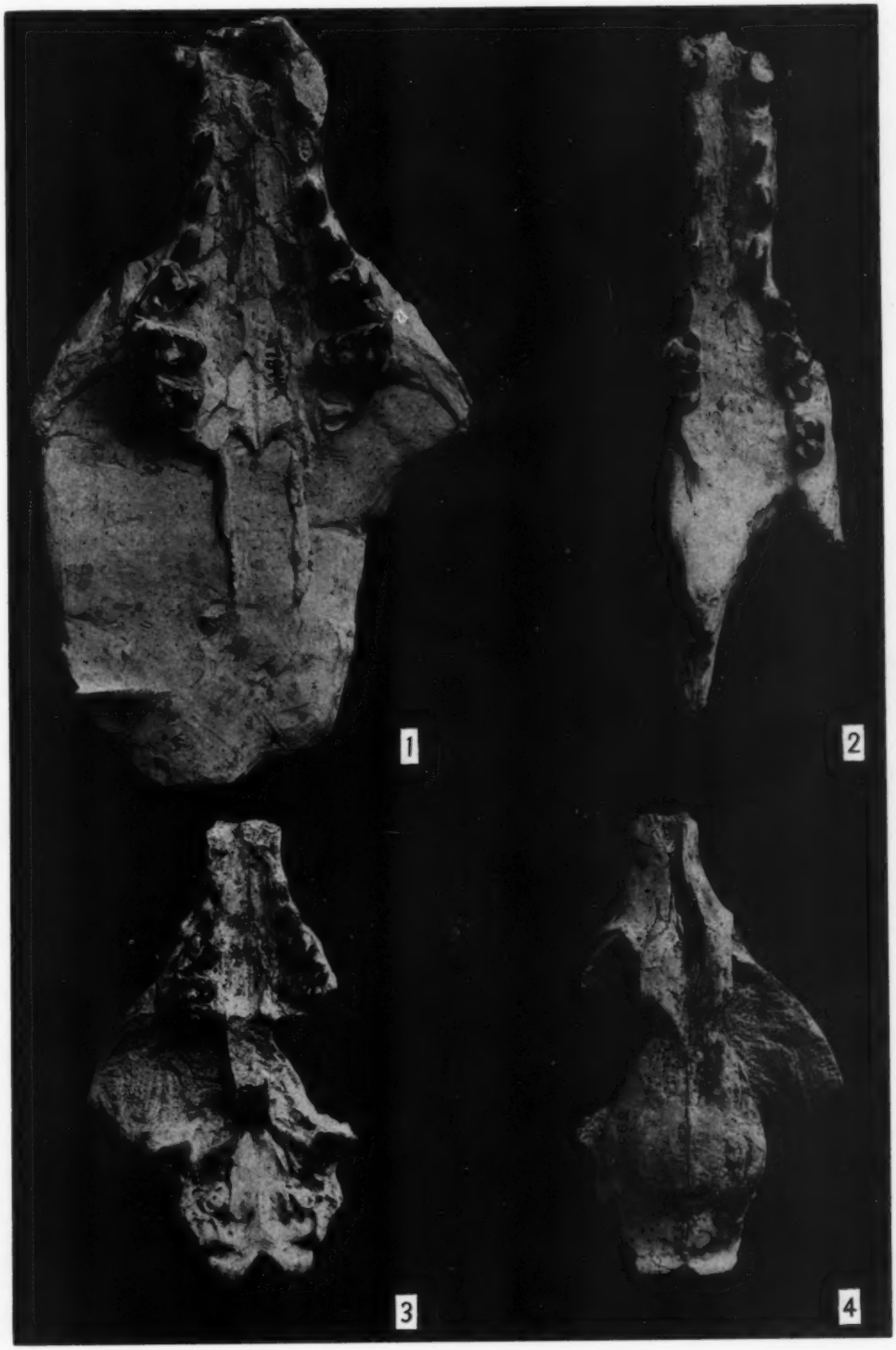
EXPLANATION OF PLATE 86

FIGS. *1, 2*—*Protemnocyon inflatus* Hatcher, USNM 17844, ×0.65. *1*, palate; note triangular shape of M^1 and M^2. *2*, crown view of lower dentition; note trenchant heel to M_1. (p. 592)

3, 4—*Daphoenus minimus* Hough, n. sp. Holotype, AMNH 39099, ×0.65. *3*, palatal view *4*, dorsal viwe of skull. (p. 589)



Hough, *Daphoenus* and Allied Genera

Hough, *Daphoenus* and Allied Genera

glenoid border. The metacromion is larger than in *Felis* and less distinct from the acromion, agreeing in this respect with *Ursus* and *Canis*. The acromion is also more like that of the Canidae and Ursidae, broad and rounded and projecting in the direction of the axillary border as well as downward. The general aspect of the scapula is similar to *Daphoenodon*.

The humerus is only slightly larger than that of the lynx but very much broader proportionally. The shaft is more curved, the deltoid ridge more prominent. The supinator ridge extends one-third the distance along the shaft and is much wider and more sharply set off from the body of the bone. The distal end of the bone is weathered so that the head and tuberosities cannot be adequately described. The external condyle and outer portion of the trochlea is also broken. The entepicondylar foramen, however, is intact and very large. The external condyle is much more prominent than in the lynx and the portion of the shaft above it more expanded.

The proximal end of the right ulna is broken and the distal end of the left ulna, but between the two the general aspect of the bone can be determined. The bone is shorter than that of the lynx, broader and much less tapering. In the Canidae the ulna is even longer and more slender. The olecranon process is partially broken but it was evidently short and thick, more like that of a bear than a dog or cat. The greater sigmoid cavity is broad and relatively shallow. The lesser cavity is triangular. The coronoid process is well defined. The relatively large articular surfaces on the ulna correspond to the larger size of the head of the radius. It is larger proportionally than in *Felis* even though the shaft of the bone is much stouter. The proximal end is also much more expanded.

The pelvis is nearly complete and articulated. It includes the crest of the ilium which is not known in any other daphoenid specimen. The general aspect is similar in many, perhaps most respects to that of the lynx, but also combines many canid and ursid features.

In the Canidae, the blade of the ilium is expanded to form a broad wing, the acetabulum faces more downward than outward and the pubes form a broad, shallow arch. The ischium is inclined laterally forming the upper margin of this arch and is produced posteriorly into a strong rugose tuberosity. In *Felis*, the ilia are slender, straight blades lying parallel to each other and the acetabulum is directed downward as in the Canidae, but the pubic arch is deep and narrow, with the ischia continuing in a straight line from the ilia and lying parallel to one another. In the bear the very massive pubic arch is broad and deep, the ilia are hugely expanded with a deeply concave outer surface. The acetabulum is directed more outward than downward and the ischia are strongly curved tuberosities.

The shape of the ilia in *Daphoenocyon* more resembles that of *Felis* than *Canis* or *Ursus*. It is broader, lower and the gluteal surface somewhat more concave than in the lynx but less so than in *Ursus*. The acetabulum faces outward as in the bears and the inner margin of the ilium where it meets the acetabulum is curved as in the bears. The shaft of the ischium is in line with the acetabulum as in *Felis* but because this protrudes outward, the two ischia are further apart and the pubic arch is broad as in *Canis* and *Ursus*.

Of the tarsals only the calcaneum is known. It closely resembles that of the lynx except that it is proportionately stouter and the tuberosity more expanded. The articular surfaces for the astragalus are longer and broader and farther apart as in the bears. The head is also more like that of *Ursus* both in being broader and having a strongly concave surface for articulation of the cuboid. In both *Felis* and *Canis* this surface is either flat or slightly convex. A cat and a dog are both, of course, strongly digitigrade and there is little play in the ankle. The bear on the other hand, and apparently *Daphoe-*

EXPLANATION OF PLATE 87

FIGS. *1*, *2*—*Daphoenocyon dodgei* (Scott), ×0.6. *1*, USNM 17847, side view of skull. *2*, Walker Museum 1456; note accessory cusps to lower premolars. (p. 594)

nocyon are plantigrade with considerable power of pronation.

The cuboid is high and narrow as in *Canis* and *Felis* but the surface which articulates with the astragalus is convex as in *Ursus* rather than flat. It is stouter and broader than in any of the modern genera.

DAPHOENODON SUPERBUS Peterson

Daphoenodon superbus, PETERSON, 1910, Mem. Carnegie Mus., vol. 4, no. 5, pp. 205–278.

Specific characters.—Incisors heavy and short; P^4 with the antero-internal cusp of moderately large size and located relatively close to the main body of the tooth. Distance from P^1 to M^3 95 mm. Maximum length of skull 253 mm.

Type.—CM no. 1589.

Locality and Horizon.—Sioux Co., Nebraska; Lower Harrison.

Specimens examined.—CM no. 1589.

Description of specimens.—*Daphoenodon superbus* is represented by a beautifully preserved skull and nearly complete skeleton, as well as parts of at least three other individuals in the Carnegie Museum, and by a skull and partial skeleton in the Amherst Museum. The Carnegie Museum material has been well described by Peterson (1910) and nothing need be added except a more detailed account of the auditory region.

Auditory region.—The left auditory region has been largely restored in plaster, the right, however, is intact and in a very good state of preservation.

The basioccipital is broad as in all of the *Daphoenus* group and the lateral margins upturned as in the bears to embrace the medial wall of the bullae. These are small and flask-shaped. The anterior medial margin extends far forward and terminates in a sharp styliform process. The anterior portion of the bulla is somewhat flattened, the posterior inflated, with the highest point about two-thirds of the way posteriorly. The medial margin is rounded and almost vertical. From there the surface curves gently to the base of the broad tubular external auditory meatus. A sharp declivity at this point produces the flattened meatus. The shape of the bulla is practically identical with that of *Amphicyon* and very characteristic.

The mastoid is well developed as a blunt truncated process. There is only a slight contact of the mastoid and the bulla. Between the two lies the very large foramen stylomastoideum definitivum. In shape and position it is similar to that of the bears. The paroccipital process is a broadly based triangle terminating in a downwardly inclined knob. The paroccipital proper extends anteriorly to form a broad concave surface, the anterior margin of which forms the posterior border of the foramen stylomastoideum definitivum. The contact of the bulla with the border of this foramen is slight. The foramen lacerum posterius is very large, and includes the posterior carotid foramen at its extreme anterior corner.

The anterior margin of the bulla is ankylosed with the base of the postglenoid process. The floor of the meatus curves anteriorly and upward forming a slight overlap on the squamosal. The latter forms the roof of the meatus. A broken edge of the meatus floor indicates that the floor was thick and filled with cancellous bone. The meatus is very broad and investigation shows that the hypotympanic sinus extended along the sides. This is exactly the condition in *Amphicyon*.

An attempt was made to clear the right bulla of plaster. This was successful as far as the removal of the plaster, but the interior structures were found to be smashed, whether before or after the restoration it is impossible to say. Enough details of the middle ear could be made out, however, to confirm the similarity with *Amphicyon*. The course of the facial canal in particular agrees with that genus, and with *Daphoenus*. The base of the mastoid process is connected with the promontorium by a ridge of bone and the facial canal passes under this ridge and leaves the skull by the stylomastoid foramen described above.

The fossa for the tensor tympani muscle is shallow as in *Daphoenus* and the epitympanic recess extends well under the roof of the meatus. As far as could be ascertained the carotid artery entered the bulla through a foramen situated on the dorsal medial curve of the medial corner of the bulla. It is included in the large foramen lacerum posterius which occupies the medial posterior corner of the auditory region.

Relationships.—The structure of the auditory region leaves no doubt of the affinity of

MEASUREMENTS IN MILLIMETERS

	Daphoenus hartshornianus		*D. velus*	
	AMNH no. 9757	Princeton no. 13450	AMNH no. 39098	AMNH no. 11857
Antero-posterior diameter of P^4	12	14	15	14
Antero-posterior diameter of M^1 and M^2	15	19	20	19
Median basal length	149	170	165	187
Maximum skull length	160	184	190	205
Width of muzzle at P^1	21	29	25	27
Width of palate at M^1	46		55	59
Length of palate	83		87	99
Distance from orbit to premaxilla	60		71	72
Length of basicranium	27			34
Maximum width of cranium	43	60	48	51

Proamphicyon (USNM no. 17842)

Antero-posterior diameter of P^4	13	Length of canine	27
Antero-posterior diameter of M^1 and M^2	18	Length of palate	92
Median basal length	172	Maximum width of cranium	31
Length of basicranium	32	Width of palate at M^1	46
Width of auditory region	18	Width of muzzle at P^1	21
Antero-posterior diameter of canine	12		

Protemnocyon

	USNM no. 17844	USNM no. 18845
Antero-posterior diameter of P^4	15	15
Antero-posterior diameter of M^1 and M^2	20	19
Length of palate	81	81 (estimated)
Width of palate at M^1	52	47
Width of muzzle at P^1	27	25
Median basal length		156
Maximum length		170
Distance from orbit to premaxilla		61
Maximum width of cranium		49
Antero-posterior diameter of canine	17	

	D. gracilis	*Pseudocynodictis*
Antero-posterior length of P^4	10	9
Antero-posterior length of M^1 and M^2	11	11
Median basal length	90 (estimated)	88
Width of muzzle at P^1	16	11
Width of palate at anterior margin of M^1	33	26
Length of palate	41	45
Distance from tip of muzzle to anterior margin of orbit	25	30
Length of basicranium (from base of postglenoid process to middle of condyle)	17	15
Maximum width of cranium	37	33

(Both specimens are somewhat flattened so that this measurement is not altogether reliable.)

Daphoenodon and *Amphicyon* or the relationship of these two genera to *Daphoenus*. An auditory region of the type of *Daphoenodon* is derivable by a process of greater ossification from the common *Daphoenus* type. That of *Amphicyon* is a further development of that of *Daphoenodon*. This already foreshadows many of the typical

ursid features. Even the shape of the bulla is very similar to that of young specimens of *Eurarctos*.

It is questionable, however, whether this really indicates a relationship in any way ancestral. There are certain ursid features in the skeleton but these are clearly parallel adaptations connected with large size and plantigrade gait.

The skull of *Daphoenodon* shows no approach to that of *Amphicyon* or the bears except the large size. The shape of the skull is essentially that of *Daphoenus* and the dentition also resembles the daphoenid group very closely except for the large size and more massive structure of the teeth. There is no approach to the elongate muzzle and peculiar dental specializations of the Ursidae. It seems probable, therefore, that *Amphicyon* and *Daphoenodon* represent different branches of the same subfamily rather than having a directly ancestral relationship and that neither was in the direct line of the bears.

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ASTRODAPSIS IN JAPAN

SYÔZÔ NISIYAMA

ABSTRACT—This paper describes a new species of *Astrodapsis*, *A. nipponicus*, from the basal part of the Suenomatsuyama formation of the Suenomatsuyama group developed in the environs of Kita-Fukuoka-machi, Ninohe-gun, Iwate Prefecture. All previously described species have come from the northwest coast of America.

IN AUGUST 1932 Mr. K. Hatai of the Institute of Geology and Palaeontology, Tôhoku Imperial University, collected numerous specimens of an interesting small echinoid from the basal part of the Suenomatsuyama formation of the Suenomatsuyama group developed in the environs of Kita-Fukuoka-machi, Ninohe District in Iwate Prefecture, Japan. These specimens together with those discovered in the collection of the Institute belong to a new species of the genus *Astrodapsis*, closely allied to *Astrodapsis tumidus* Rémond. It is the first record of the genus in Japan.

Family SCUTELLIDAE L. Agassiz
Genus ASTRODAPSIS Conrad, 1857

1857. *Astrodapsis* CONRAD, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 315. (Sole species *Astrodapsis antiselli* Conrad.)
1857. *Astrodapsis* CONRAD. Conrad in Antisell, Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean, vol. 7, Rept. on Paleo., p. 196.
1863. *Astrodapsis* CONRAD.? RÉMOND, Proc. Calif. Acad. Sci., vol. 3, p. 52.
1914. *Astrodaspis* Conrad. LAMBERT et THIÉRY, Essai de Nomenclature Raisonnée des Échinides, fasc. 4, p. 314 (spelling corrected to *Astrodapsis*, p. 582).
1915. *Astrodapsis* Conrad. CLARK and TWITCHELL, U. S. Geol. Survey Monogr. 54, p. 197.
1920. *Astrodapsis* Conrad. KEW, Univ. Calif. Publ. Bull. Dept. Geol., vol. 12, no. 2, p. 78.
1925. *Astrodapsis* Conrad. LAMBERT et THIÉRY, *op. cit.*, fasc. 8–9, p. 582.
1935. *Astrodapsis* Conrad. RICHARDS, San Diego Soc. Nat. Hist. Trans., vol. 8, no. 9, p. 60.
1938. *Astrodapsis* Conrad. GRANT and HERTLEIN, Univ. Calif. at Los Angeles Publ. in Math. and Phys. Sci., vol. 2, p. 68.

Genotype (by monotypy), *Astrodapsis antiselli* Conrad. The holotype of the genotype has been figured by Richards (1935, pl. 7, figs. 1 a–b); it is from Estrella, Monterey County, California, upper Miocene, Catalogue No. 13337 in the U. S. National Museum.

Original description: "Suboval; depressed; ambulacral areas elevated or ridged; ambulacra nearly straight, widely open at the extremity; mouth central; anus submarginal, beneath; radiating grooves as in *Laganum*."

Diagnosis.—Test more or less depressed; thickly subdiscoidal to broadly subconical in shape; margins subcircular to subelliptical, with the anteroposterior diameter usually exceeding the transverse; margin variable, quite thin to very thick and swollen, and with or without notches in the ambulacral and interambulacral areas. Petaloid areas of the ambulacra more or less elevated or ridged, interambulacral areas more or less depressed; auxiliary grooves may be present in the ambulacral areas along the sides of the petals; petals straight, extending close to margin, and wide open at the distal ends. Poriferous zones nearly parallel, or continuously alternatingly divergent; ambulacral petals begin to broaden before reaching the end of the petal; aporidic pores usually continue to the margin beyond the petal proper. Apical system central or subcentral, more or less depressed below inner portions of petals; four genital pores present, the interambulacrum 5 being absent. Summit of test central or anteriorly eccentric. Actinal surface flat or more or less concave orally. Peristome central or subcentral, rounded subpentagonal. Periproct round, inframarginal to marginal, never supramarginal. Main actinal ambulacral furrows are usually well marked, broad, perforated, and continue from the peristome to the margin, often extending as faint grooves on the upper surface nearly to the apical system and

forming a median line on petals. Indistinct lines of grooves may be thrown off from the main furrows when about two-thirds the distance to the margin, and these usually extend on to the abactinal surface as sutural lines between the interambulacral and ambulacral areas. Tuberculation prominent, scrobicular, of uniform size, or larger on the petaloid parts of the ambulacra and actinal surface. Internal structure similar to that of *Echinarachnius;* consists of strong radiating partitions which connect with the roof for one-fourth to one-half the distance to the peristome and then continue as low ridges on the floor, concentrically placed ridges are situated marginally, or absent, connecting the radiating partitions, which limits ambulacra; remainder of the floor more or less roughened; perignathic girdles rather high; auricles fused into a single piece and placed on each interambulacrum; jaws relatively low, with ringing laminae on either side of the superior horizontal teeth as in *Echinarachnius;* pyramids unequal.

This genus has hitherto received relatively little attention. Some authors placed its species in the genus *Scutella*,[1] others in the genus *Echinarachnius*,[2] while the majority insisted on uniting the species with the genus *Clypeaster*.[3] Duncan (1889, p. 165) considered this genus as a synonym of *Arachnoides*,[4] but Clark and Twitchell (1915, p. 197) disagreed with this view. They distinguished *Astrodapsis* from *Arachnoides* by the inframarginal position of the periproct, the depressed apical system, and the elevated ambulacral areas alternating with depressed interambulacral areas. With abundant specimens at hand they revised the generic diagnosis. Kew (1920), in his studies of the fossil echinoids from the Cenozoic deposits of California, revised the species of the genus and added 12 new species and subspecies, the majority being derived from the Miocene deposits of California. Unfortunately, a discussion of the affinities of this genus, detailed observations on the internal structure and especially remarks on the perignathic girdles and auricles were not given in this work. The Japanese specimens which belong to *Astrodapsis* take the following description.

ASTRODAPSIS NIPPONICUS Nisiyama, n. sp.
Plate 88, figures 1–6, 8, 10–13

Holotype.—One complete specimen, Institute of Geology and Palaeontology, Tôhoku Imperial University, Sendai, No. 60326a. Collected by K. Hatai, August 1932.

Paratypes.—Sixteen specimens, deposited in: Inst. of Geol. and Palaeont., Tôhoku Imperial Univ., No. 60326; Stanford Univ. Paleo. Type Coll., No. 7952; Calif. Acad. Sci. Paleo. Type Coll.; United States National Museum. Collected by K. Hatai, August 1932.

Referred specimens.—Thirteen specimens from Neko-buchi, Nisatai-mura, Ninohe District, Iwate Prefecture, Inst. of Geol. and Palaeont., Tôhoku Imperial Univ., No. 22034, collected by S. Shimizu, precise locality somewhat doubtful. Two specimens from near (?) Kintaichi Station on the main Tôhoku Railway Line, Ninohe District, Iwate Prefecture, Inst. Geol. and Palaeont., Tôhoku Imperial Univ., No. 22047, collected by H. Matsumoto, precise locality somewhat doubtful.

Locality of holotype and paratypes.—In a

[1] *Scutella* LAMARCK, 1816 (Anim. s. Vert., vol. 3, p. 7). Genotype (according to L. Agassiz, Echin. Viv. Foss., Second Monogr. Scutel., 1841, pp. 4–5, and H. L. Clark, 1911, Ann. Mag. Nat. Hist., ser. 8, vol. 7, p. 605): *Echinodiscus subrotundus* Leske, from the Miocene of Bordeaux.

[2] *Echinarachnius* GRAY, 1825, Ann. Phil., vol. 26 (n.s., vol. 10), p. 428. Genotype (according to L. Agassiz, *op. cit.*, p. 88 and H. L. Clark, *op. cit.*, p. 605): *Scutella parma* Lamarck, from the Recent of Canada. (Figured by L. Agassiz, *op. cit.*, 1841, p. 89, pl. 20, figs. 7–18.)

[3] *Clypeaster* LAMARCK, 1801, Syst. Anim. s. Vert., vol. 1, p. 349. Genotype (designated by H. L. Clark, 1911, Ann. Mag. Nat. Hist., ser. 8, vol. 7, p. 604): *Echinus rosaceus* Linnaeus, 1758, from the Recent of the Caribbean region. (Figured by A. Agassiz, 1873, Mem. Mus. Comp. Zool., Harvard, vol. 3, pt. 3, pls. 11c; 11d, figs. 1–2; 11f, figs. 1–18; 13, fig. 1; 25, fig. 23; 27, fig. 6; 28, figs. 1–2; 37, figs. 9, 11.)

[4] *Arachnoides* LESKE, 1778, Add. ad Klein., p. 154. Genotype (according to L. Agassiz, *op. cit.*, 1841, and H. L. Clark, *op. cit.*, 1911): *Arachnoides echinarachnius* Leske, 1778 = *Echinus placenta* Linnaeus, 1758, from the Recent of the South Seas. (Figured by L. Agassiz, 1841, p. 94, pl. 21, figs. 35–42, and by Mortensen, Vid. Midd., vol. 73, pl. 6, figs. 26–27, 1921.)

fine conglomeratic sandstone at the southern margin of the tributary of the Mabechi-gawa, about 150 meters east of the bridge connecting Kita-Fukuoka-machi with Itsuka-machi, Ninohe District, Iwate Prefecture, Japan. Basal part of the Suenomatsuyama formation of the Suenomatsuyama group. Mio-Pliocene.

Dimensions.—The 31 specimens referred to this new species range from 16 mm. to 26 mm. in longitudinal diameter. Holotype, 24 mm. in longitudinal diameter, 22 mm. in transverse diameter, 8 mm. in height.

Description.—Test small, stout, ovoid in marginal outline; margin thick, depressions prominent in ambulacra I and V, interambulacrum 5 produced posteriorly; upper surface moderately arched, posterior part more sharply arched than the anterior; marked depressions in interambulacral areas, especially in interambulacrum 5. Actinal surface more or less concave to peristome. Ambulacra, petaloid area 20 mm. in length; petals prominently elevated, widely open and extending about two-thirds of distance to margin of test; pores conjugate, inner rows of pores straight, outer rows more or less incurved at middle of petals; petal III 6 mm. long, over 5 mm. wide at distal end poriferous areas about 1 mm. wide, 23 pore-pairs in each side; petals II and IV about 7 mm. long and nearly 5 mm. wide at distal ends, having 24 pore-pairs in each side, angles between middle line of petal III and that of petals II and of IV about 70° in each side; petals I and V about 8 mm. long and about 5 mm. wide, 27 pore-pairs in each side, angles between middle lines of petals I and V and that of petals II and IV make about 80° in each side, and angle between middle line of petal I and that of petal V about 60°. Apical system situated at 12 mm. from anterior margin, or little eccentric to anterior, madreporic area pentagonal in outline, 4 mm. long by 4 mm. wide, with numerous madreporic pores. Peristome sunken, situated at 13 mm. from anterior margin of test, 2 mm. long by 2.5 mm. wide, subpentagonal in outline. Periproct rather small, elongated transversely, 1 mm. long and 0.7 mm. wide, situated at 2 mm. from the posterior margin. Actinal ambulacral furrows more or less distinct, broad, straight, pointed to ambulacral depressions. Tuberculation distinct, similar on both surfaces, rather coarse, about 25 primary tubercles in 3 sq. mm. at interambulacrum 4 of actinal surface, perforated; scrobiculae of medium size. Internal structure (in paratype) consists of pair of stout and radiating partitions in each interambulacrum close to ambulacra, which extend to roof at about half the distance from ambitus to peristome. Perignathic girdle rather high, situated at 1.5 mm. from the margin of peristome.

Variation.—In general, the variation of the marginal outlines usually lies in the limit of ovoidal fluctuation. The main trends observed in the post-larval development (fig. 13 a–f) are: (1) increase in the degree of elevation of ambulacra and of depression of interambulacra; (2) increase in the degree of depression of the apical system; and (3) slight increase in breadth. These changes seem to appear suddenly in growth stages between 18 and 20 mm. in longitudinal diameter.

Distinctions.—This species resembles *Astrodapsis tumidus* Rémond (figs. 7, 9), from the upper Miocene of California, but is easily distinguished by its shorter and straight petals and the angles between the median lines of each petal, by the more arched profile, the depressed apical system, and by the highest point, which is situated posteriorly. It is also distinguished from the American species by the position of the periproct, which is close to the ambital margin in the latter and far apart in the former. The radiating partitions, which extend half way to the peristome from the margin, and the lack of concentric pillars also serve to distinguish the present species from the American one.

Distinct depressions of the interambulacra are not attained until the test diameter reaches 18 mm., but well marked depressions of the interambulacra are developed when the test attains about 20 mm. or more in longitudinal diameter. Full-grown specimens probably do not exceed 30 mm. in length.

Astrodapsis nipponicus is distinguishable from all other species of the genus by: (1) the position of the periproct, (2) the size and pattern of the petaloid area, and (3) the small size of the test. The small size of this species may suggest immaturity, unfavor-

able ecological conditions, or arrested evolution. There may also be other biological factors.

Remarks.—Besides occurring in Honshû, *Astrodapsis* also occurs in the Neogene deposits of Kamchatka and Sakhalin, as shown in the annexed list. Its occurrence from Hokkaidô is to be expected, from the geographical position of the island. Since only very doubtful specimens of the genus from Hokkaidô are now in the collection at hand, they are not included in the list.

1. *Astrodapsis* cf. *A. fernandoensis* Pack. KHOMENKO, 1931, Trans. Geol. and Prospect. Serv., U.S.S.R., fasc. 79, pp. 27, 115. "North of Okha, Eastern Sakhalin; Nutovo series, middle Pliocene."
2. *Astrodapsis pabloensis* Kew. KHOMENKO, 1931, Mem. Soc. Russ. Miner., vol. 60, p. 106. "Baron Korf Gulf, Kamchatka. Middle Miocene."
3. *Astrodapsis tumidus* Rémond. KHOMENKO, 1931, Trans. Geol. and Prospect. Serv., U.S.S.R., fasc. 79, pp. 27, 115, pl. 1, fig. 4. "North of Okha on the right bank of a rivulet draining into the Nautu Gulf, Eastern Sakhalin. Nutovo series, middle Pliocene."
4. *Astrodapsis whitneyi* Rémond. ARGAMAKOVA, 1934, Trans. Oil Geol. Inst., ser. A, fasc. 41, pp. 28, 41. "Boatassin district, Sakhalin. Upper Notovo series, upper Pliocene?"

ACKNOWLEDGMENTS

Acknowledgments are made to the following: Colonel Hubert G. Schenck, Chief of the Natural Resources Section of the Supreme Command for the Allied Powers and Professor at Stanford University, California, for kindly reading and making possible the publication of this paper; Dr. H. Yabe, formerly Professor of the Tôhoku Imperial University, Sendai, for his encouragement; Mr. K. Hatai of the Institute of Geology and Palaeontology, Tôhoku Imperial University, Sendai, for his kind advice on many questions concerning the present work; the late Dr. S. Nomura, formerly Curator of the Saito Hô-on Kai Museum, Sendai, for his generous loan of Northwest American specimens used for comparison in the present work; Mr. K. Kumagai of the Institute of Geology and Paleontology, Tôhoku Imperial University, Sendai, for his photographic work; and Dr. Myra Keen of Stanford University for transmitting the paper for publication.

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EXPLANATION OF PLATE 88

FIGS. *1, 5, 10—Astrodapsis nipponicus* Nisiyama, n. sp. Holotype, ×2.2. *1*, abactinal view; *5*, actinal view; *10*, lateral view. No. 60326a, Institute of Geology and Palaeontology, Tôhoku Imperial University, Sendai; from the Suenomatsuyama formation in Kita-Fukuoka-machi, Iwate Prefecture, Japan. (p. 602)

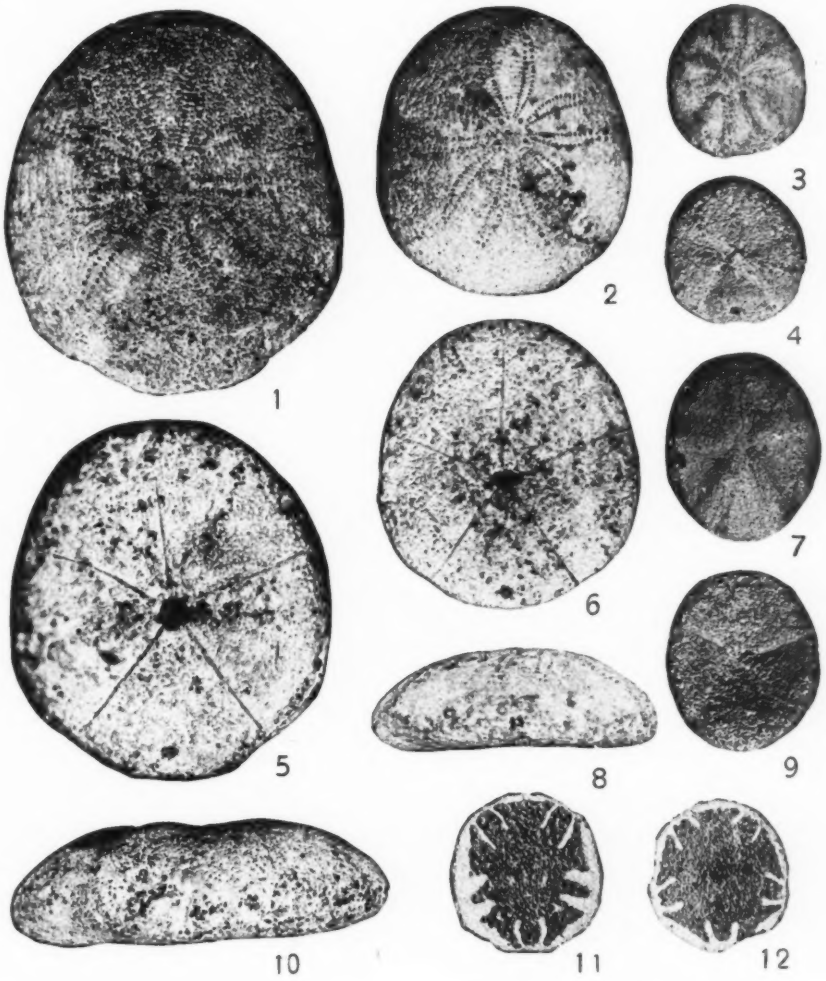
2, 6, 8—Astrodapsis nipponicus Nisiyama, n. sp. Paratype, ×2.2. *2*, abactinal view; *6*, actinal view; *8*, lateral view. No. 60326, Inst. Geol. Palaeont., Tôhoku Imp. Univ. Same locality as fig. *1*. (p. 602)

3, 4—Astrodapsis nipponicus Nisiyama, n. sp., ×1. *3*, abactinal view; *4*, actinal view. No. 22034, Inst. Geol. Palaeont., Tôhoku Imp. Univ. From Neko-buchi, Nisatai-mura, Ninohe District, Iwate Prefecture, Japan. (p. 602)

7, 9—Astrodapsis tumidus Rémond. Hypotype, ×1. *7*, abactinal view; *9*, actinal view. Department of Geology, Saito Hô-on Kai Museum, Sendai. From the Santa Margarita formation in California. (p. 603)

11, 12—Astrodapsis nipponicus Nisiyama, n. sp. Paratype, ×1. *11*, internal structure on actinal view; *12*, internal structure on abactinal view. Reg. No. 60326, Inst. Geol. Palaeont., Tôhoku Imp. Univ. Locality as in Fig. *1*. (p. 602)

13 a–f—Astrodapsis nipponicus Nisiyama, n. sp. ×1. Diagrammatic figures of ontogenetic development. (p. 602)



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MANUSCRIPT RECEIVED AUGUST 1, 1947.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 5, PP. 606–607, SEPTEMBER 1948

ARBIA AND *DIXIEUS*, TWO NEW GENERA OF ECHINOIDS

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U. S. Geological Survey

ARBIA

THE late Oligocene species from Alabama described by W. B. Clark (1915, p. 158, pl. 73, figs. 6a-b, 7a–c) under the name *Coelopleurus aldrichi* and later transferred to *Arbacia* by Cooke (1941, p. 11) appears to be neither a *Coelopleurus* nor an *Arbacia* though it possesses some of the characters of both genera. A new genus, *Arbia*, is here proposed to receive it.

Genus ARBIA Cooke, n. gen.

Apical system probably dicyclic, pentagonal, encircling the periproct. Ambulacra narrower than the interambulacral areas throughout; poriferous zones uniserial, the zygopores forming a straight line above the ambitus, arranged in slightly diagonal groups of three at and below it, not at all expanded at the peristome; zygopores one to each plate near the apex, three to each compound plate below; without sphaeridial pits. Tubercles imperforate, more abundant below the ambitus. Peristome small, circular, moderately notched.

Type species, *Coelopleurus aldrichi* Clark = *Arbia aldrichi* (Clark).

Arbia bears a superficial resemblance to *Coelopleurus* and *Arbacia*, from both of which it differs in the presence of simple plates in the upper part of the ambulacra, in the total lack of sphaeridial pits (*Arbacia* has one, *Coelopleurus* about eight), in its much smaller, nearly circular peristome, and in its lack of callous coatings at its notches. From *Arbacia* it differs further in the narrowness of its ambulacra and poriferous zones at the peristome. *Arbia* lacks the nodular cord that surrounds the ambulacral areas in *Coelopleurus*. The decoration of the type species is more like that of most species of *Arbacia* than of *Coelopleurus;* it suggests that of *Phymosoma*, which, however, has a quite different arrangement of the zygopores and a much larger, caducous apical system.

DIXIEUS

Erection of a new genus, *Dixieus*, seems required to receive *Phymosoma dixie* Cooke (1941, p. 17, pl. 2, fig. 15; pl. 4, figs. 1, 2, 9), from the late Eocene Ocala limestone of Florida, and *Phymosoma peloria* Arnold and Clarke (1927, p. 18, pl. 2, figs. 1–3), probably from the late Eocene of Jamaica, which differ notably from *Phymosoma koenigi* (Mantell) (Wright, 1864, p. 131, pls. 23, 24; pl. 25, fig. 3; pl. 26, fig. 1), the type species of *Phymosoma* d'Archiac and Haime (1853, p. 86), from the Upper Cretaceous White Chalk of England.

The most significant difference is found in the number of pores in the upper part of the ambulacra, where the zygopores are arranged in two rows in each species, but in *Phymosoma koenigi* there are two rows of only three zygopores each (six zygopores in all) in each compound plate, whereas in *Dixieus dixie* and *D. pelorius* there are two rows of six zygopores each (12 zygopores in all) in each compound plate.

The apical systems also differ. That of *Phymosoma koenigi* is caducous and the arrangement of plates is unknown. Its scar is large, occupying about one-third of the horizontal diameter; it is pentagonal, and one prong is longer than the others and points to a slight depression in the adjoining interambulacral area. The apical system of *Dixieus dixie* is proportionately only about half as large, its outline is equilateral pentagonal, and its plates are preserved in the type and a topotype, the only specimens that I have seen. The apical system of *D. pelorius* is caducous, but its outline is proportionately about the same size and shape as that of *D. dixie*.

The shape of *Phymosoma koenigi* is discoid, like a cartwheel; that of *D. dixie* and *D. pelorius* is more tumid on top and more depressed around the peristome.

The peristome of *P. koenigi* is smaller and less deeply notched than that of *D. dixie*.

The peripheral tubercles of *P. koenigi* are proportionately larger than those on the remainder of the test, whereas in *D. dixie* and *D. pelorius* the tubercles are evenly graded and those on the ambitus are little larger than the others.

Genus DIXIEUS Cooke, n. gen.

Test low-arched above, rounded below. Apical system small, pentagonal, equilateral, composed of five genital plates and five ocular plates, the anterior and right anterior ocular plates nearly or quite reaching the periproct, the other ocular plates widely insert. Periproct central, comparatively large. Peristome large, circular, deeply notched, depressed. Ambulacra evenly expanded to the ambitus, where they are more than half as wide as the interambulacral areas; plates somewhat wider than high, each bearing one central, primary, crenulated, imperforate tubercle; poriferous zones above the ambitus consisting of two vertical rows of zygopores, about 12 zygopores to each compound plate, becoming somewhat disordered near the ambitus, and changing below the ambitus to one row of open, connected arcs, one arc of about six zygopores to each compound plate, breaking into two diagonal rows of three near the peristome. Interambulacral plates about as high as the ambulacral but somewhat wider, each bearing one central, imperforate, crenulated primary tubercle. Tubercles evenly graded.

The name is derived from Dixie County, Florida, where the type species occurs.

Type species, *Phymosoma dixie* Cooke = *Dixieus dixie* (Cooke).

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JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 5, PP. 608–616, PLS. 89–91, SEPTEMBER 1948

LOWER CRETACEOUS CORALS FROM TRINIDAD, B. W. I.

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ABSTRACT—Limestone blocks found in the beds of several streams in the Central Range of Trinidad, B. W. I., contain fragments of corals representing the Urgonian (Barremian-L. Albian) reef-coral fauna of America and Europe. The blocks seem to represent a stratigraphic unit older than the Aptian Cuche formation, a unit not yet found in situ. Twelve genera, including 14 species, have been identified. Seven species are new, six are related to or identical with forms previously known from the American Lower Cretaceous. One species, *Stylina harrisoni*, originally described from Trinidad as the type of a new genus, *Dendroseris*, is redescribed from topotype material.

INTRODUCTION

SEVERAL years ago the writer received several blocks of limestone containing fossil corals from new localities in the Central Range of Trinidad, from the Naturhistorisches Museum in Basel (Switzerland), through the kindness of Dr. R. F. Rutsch. The material proved of considerable interest as representing a more easterly occurrence of the Lower Cretaceous "Urgonian" reef-coral fauna already known from Texas (Wells, 1932), southern Mexico (Felix, 1891), and northeastern Venezuela (Wells, 1944). Later, thanks to Dr. H. G. Kugler of Trinidad Leaseholds, Ltd., more coralliferous blocks were obtained from two other sites in the Central Range. From this material a total of 12 scleractinian genera represented by 14 species has been determined, and is described below. The writer here expresses his appreciation to Drs. Rutsch and Kugler for the opportunity of going over this collection.

LOCALITIES AND MATERIALS

The coralliferous blocks came from the following localities:

1. *Cush River* (Mitan River), crossing N-S line of Range Reserve. Isolated small block in river bed. (Collected by R. Rutsch, Gunther, Spaenhauer, and Renz, Loc. No. G2210A: N. 325,000 links, E. 536,500 links.) These coordinates apply to the map of Trinidad published by Vaughan and Cole (1941, pl. 3).

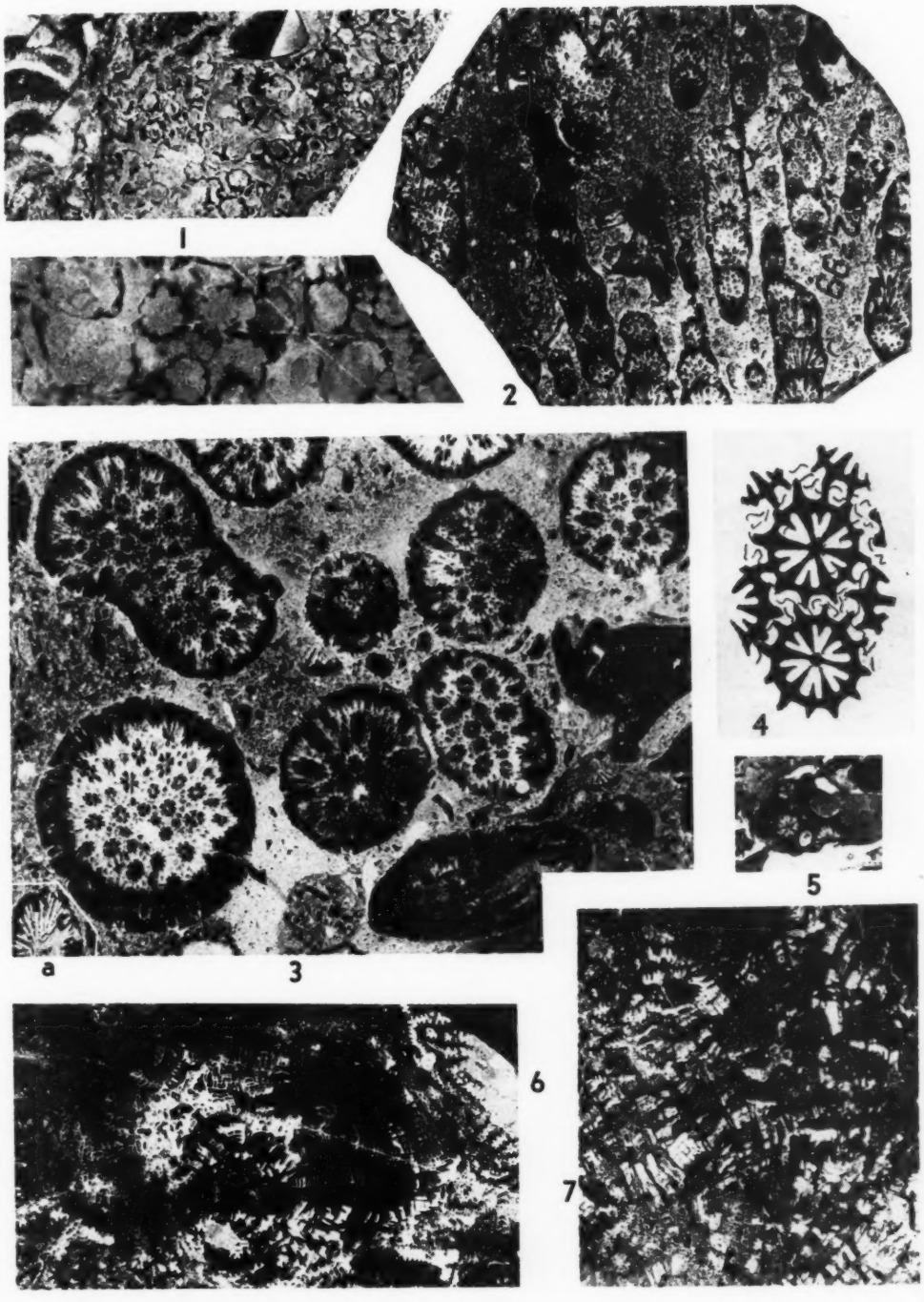
2. *Swiss River*. Numerous large boulders in river bed. (Collected by R. Rutsch, Gunther, Spaenhauer, and Renz, Loc. No. G3687: N. 332,500 links, E. 539,500 links.)

3. *Baccus River*, side branch, Charuma area. Worn boulder. (Collected by A. E. Gunther, Loc. No.5181: N. 300,500 links, E. 467,200 links.)

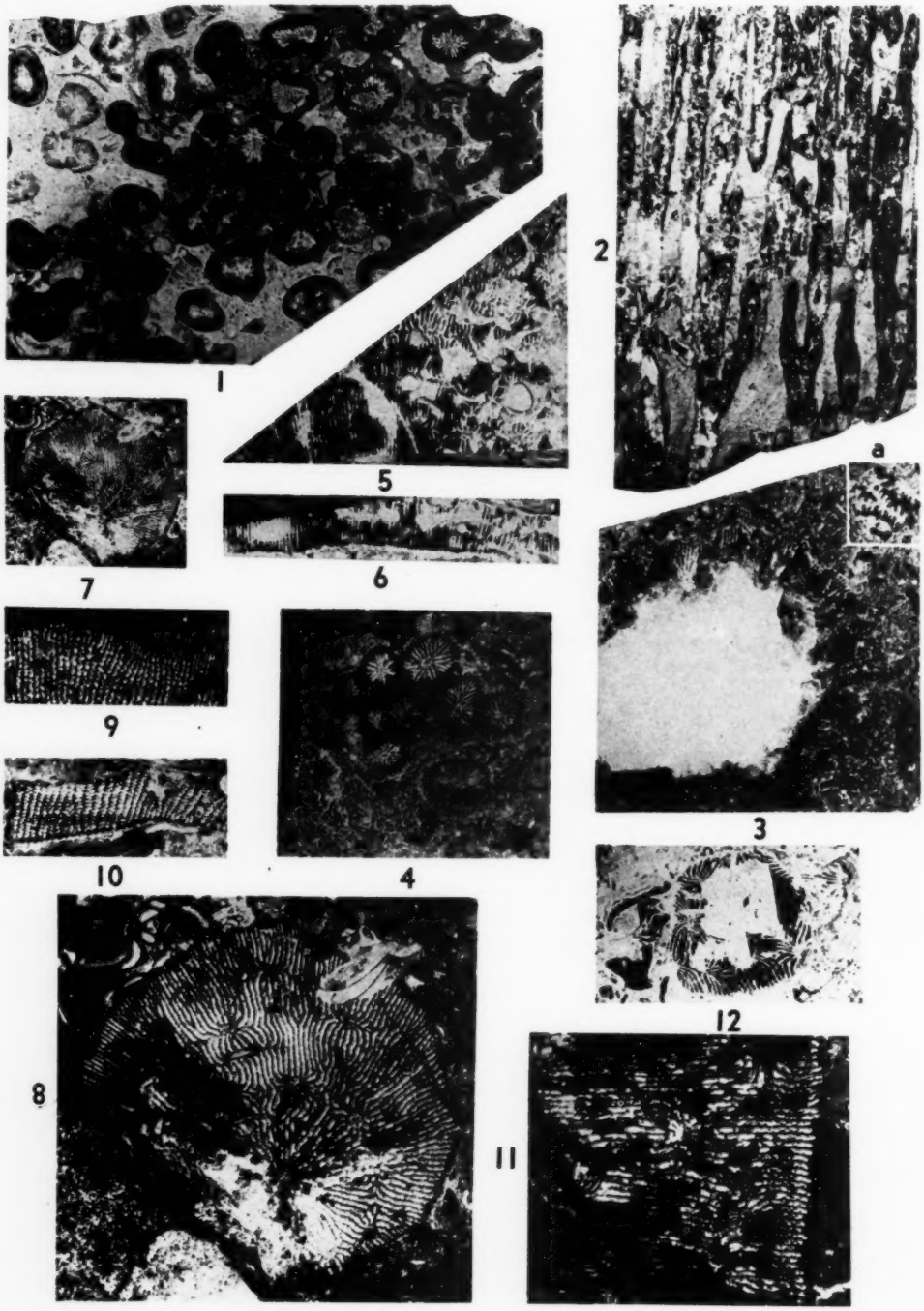
4. *Piparo River*, 2000 links NNE. of Piparo R. bridge on Rebecca Richmond Trace, Tabaquita area. Several boulders on river flat. (Collected by K. Rohr, Loc

EXPLANATION OF PLATE 89

FIG. *1*—*Cyathophora parvula* Wells, n. sp., holotype (USNM 104248), Piparo River. Above, trans. section, ×2¼; below, ×6. (p. 609)
2, 4—*Stylina harrisoni* (Gregory) (USNM 104249), Cush River. *2*, natural vert. section, ×0.65; *3*, trans. section of branches, ×2¼; *4*, trans. section of corallites, ×10. (p. 610)
5—*Stylangia laddi* Wells (USNM 104250), Baccus River. Fragment of corallum, ×1. (p. 611)
6—*Myriophyllia cuyleri* Wells (USNM 104252), Piparo River. Section of corallum, ×1. (p. 611)
7—*Myriophyllia trinitatis* Wells, n. sp., holotype (USNM 104253), Swiss River. Section of corallum, ×2¼. (p. 612)
3a—*Calamophyllia sandbergeri* Felix (USNM 104249), Cush River. Trans. section of corallite, ×2¼. (p. 612)



Wells, Lower Cretaceous Corals from Trinidad



Wells, Lower Cretaceous Corals from Trinidad

K. R. 15552: N.279,490 links, E. 427,680 links.)

THE CORAL FAUNA AND ITS AGE

The only previous record of Lower Cretaceous corals in Trindad was by the late J. W. Gregory (1929) who described what he regarded as a new new fungiid coral genus, *Dendroseris* (identified with *Stylina* in the present paper), based upon a specimen found in a loose limestone block from the vicinity of Bousignac on the Cush River, and believed to be of Middle Cretaceous age.

The new material from the localities described above represents a formation which has not yet been found in place and which is known only from loose blocks. The blocks are a zoogenic limestone composed largely of worn fragments of corals, sponges, echinoderms, pelecypods, and nerineid gastropods. The preservation of the corals leaves much to be desired, occurring as they do as worn fragments in worn pieces of tough limestone. All had to be studied by slicing the blocks, and few of the figures show other than sections of the various species. The species identified and their distribution are listed in Table I.

The coral fauna, in spite of its new elements, thus shows strong affinities with that in the upper part of the Barranguin formation (upper Aptian) of northeastern Venezuela recently described by the writer (1944), with that in the Barremian-Lower Albian of Tehuacan, southern Mexico (Felix, 1891), and with that in the lower part of the Glen Rose formation (lower Albian) of central Texas (Wells, 1932). One species is close to *Montlivaltia burckhardti* Wells from the lower Hauterivian of northern Mexico.

As mentioned above, the coralliferous limestone has not yet been found in place in Trinidad. Its facies is different from that of the oldest bedrock now known from the Central Range region,—the Cusche (Cush) formation of Aptian age (Renz, 1942, p. 523), the base of which is unknown. The oldest rocks in Trinidad are the late Jurassic limestones in the Northern Range* (Renz, 1942, p. 520), but the Central Range boulders and blocks are not related to these. They may represent either a zoogenic limestone facies of the Cuche formation, or possibly a still older Aptian formation below the Cuche.

DESCRIPTION OF SPECIES

Family STYLINIDAE
Subfamily CYATHOPHORINAE
Genus CYATHOPORA Michelin, 1843
CYATHOPHORA PARVULA Wells, n. sp.
Plate 89, figure 1

Description.—Corallum small, irregularly nodular, the holotype being about 30 mm. long with a maximum width or height of 15 mm. Corallites cylindrical, small, averaging 1 mm. in diameter, with occasional ones up to 1.5 mm., closely packed, from 0.2 to 0.5 mm. apart, with thin but continuous walls marked externally by very low first cycle costae. Septa very small and rudimentary, in two regular cycles (6/6), those of the first cycle thick at the wall but tapering rapidly inward and extending about one-third the distance to the axis; those of the

* After completion of this paper, Dr. Kugler sent the author two specimens from a limestone west of Reefs Point, Toco, northeast Trinidad, in the Northern Range. One of these is *Myriophyllia cuyleri*, which seems to indicate the presence of the Lower Cretaceous at that place.

EXPLANATION OF PLATE 90

FIG. *1, 2—Calamophyllia sandbergeri* Felix (USNM 104255), Swiss River. *1*, trans. section of corallum, ×1; *2*, natural vert. section of corallum, ×0.6. (p. 612)

3, 4—Ovalastrea rutschi Wells, n. sp., holotype (USNM 104253), Swiss River. *3*, vert. section of corallum, ×2; *4*, trans. section of corallites, ×2¼. (p. 613)

3a—Myriophyllia trinitatis Wells, n. sp., holotype (USNM 104253), Swiss River. Trans. sec) tion of corallites, ×2¼. (p. 612)

5, 6—Thamnasteria? piparensis Wells, n. sp., holotype (USNM 104257), Piparo River. *5*, transsection, ×2¼; *6*, vert. tang. section, ×2¼. (p. 614)

7–11—Protoseris? incerta Wells, n. sp., *7, 8*, holotype (USNM 104256), trans. sections of colony, ×1, ×2¼. *9, 10*, same, vert. tang. sections, ×2¼. *11*, paratype, trans. section, ×2¼. All from Baccus River. (p. 613)

12—Synastrea sp. cf. *S. crespoi* (Felix) (USNM 104258), Piparo River. Trans. section of worn fragment, ×1. At left is vert. section of young colony of *Microsolena kugleri* Wells, n. sp. (p. 615)

second cycle mere ridges on the inner surface of the wall, often not observable. Costae very short, not meeting those of adjoining corallites. Endothecal dissepiments thin, irregularly tabular, about 3 per mm; exothecal dissepiments thin, strongly concave to the outer surface, about 3 per mm.

Occurrence and material.—Lower Cretaceous, Piparo River, Central Range, Trinidad: holotype. USNM No 104248.[1]

Remarks.—This species, although based upon a very imperfect specimen, is so clearly distinguished by its very small corallites from other American Cretaceous forms of the genus that it is named here. It is apparently closely allied to *C. pygmaea* Volz (1903, p. 26, pl. 4, figs. 4–7) from the Neocomian of Bukowina, which has corallites about the same size.

[1] All types have been deposited in the United States National Museum. Where possible, duplicates will be sent to the Naturhistorisches Museum, Basel.

Subfamily STYLININAE
Genus STYLINA Lamarck, 1816
STYLINA HARRISONI (Gregory)
Plate 89, figures 2, 3, 4

Dendroseris harrisoni GREGORY, 1929, Geol. Mag., vol. 66, p. 65, pl. 8.

Description.—Corallum ramose, in the form of large clumps of slender, blunt, columniform, erect branches, 8 to 15 mm. in diameter, and a decimeter or more in height. Corallites plocoid, about 1.5 mm. in outside diameter (1 mm. inside), united by stout, non-confluent costae and some exotheca, about 0.6 mm. apart. Septa arranged 6/6 with the first cycle of very stout septa reaching to the columella, and the second cycle mostly rudimentary. Columella a styliform pillar, well-developed.

Occurrence and material.—Lower Cretaceous, Cush River, Central Range, Trinidad: one specimen, USNM No. 104249. Type locality: limestone blocks at Bousignac on the Cush River. Type specimen: Geological Museum, Glasgow, No. C4151.

TABLE I.—OCCURRENCE OF CORALS IN THE LOWER CRETACEOUS OF TRINIDAD

	Cush	Swiss	Baccus	Piparo	Elsewhere
Cyathophora parvula, n. sp.				x	*C. pygmaea*, Neocomian of Bukowina
Stylina harrisoni (Gregory)	x				
Stylangia laddi Wells			x	x	Barranquin fm., N.E. Venezuela
Myriophyllia cuyleri Wells				x	Glen Rose fm., Texas
Myriophyllia trinitatis n. sp.		x		x	
Calamophyllia sandbergeri Felix	x	x		x	Barranquin fm., Venezuela; Aptian, Tehuacan, Mexico
Ovalastrea rutschi n. sp.		x		x	
Protoseris ? incerta n. sp.			x		
Thamnasteria ? piparensis n. sp.				x	
Synastrea cf. *S. crespoi* (Felix)			x	x	Aptian, Tehuacan, Mexico
Microsolena kugleri n. sp.				x	
Microsolena delicatula n. sp.			x		
Montlivaltia cf. *M. burckhardti* Wells			x		Hauterivian, N. Mexico
Elasmophyllia tolmachoffana Wells				x	Glen Rose fm., Texas; Barranquin fm., Venezuela

Remarks.—The writer has already suggested (1942, p. 128), on the basis of examination of Gregory's holotype of *D. harrisoni*, that the supposed fungiid genus *Dendroseris* Gregory is merely a ramose *Stylina*. Study of the new specimen also fails to reveal the synapticulae characteristic of fungiid corals. It is true that what seems to be a beaded structure appears in certain longitudinal sections of the corallites where the inner ends of the septa are marked by trabecular processes or attachments to the columella. These might be mistaken for synapticulae. Other fungiid characters such as perforate walls and confluent, perforated septa, are not present. On the other hand the solid walls, limited number of septa, styliform columella, and non-confluent costae, are clearly indicative of a stylinid.

Not many Cretaceous Stylinae are known, and all of them, with the exception of *S. harrisoni*, have massive, nodular, or laminate coralla. Another possible exception is *S. steinmanni* de Angelis d'Ossat (1915, p. 29, pl. 2, fig. 11) from the Urgonian of Capri, which has smaller and more distantly spaced corallites. This form, however, is not certainly *Stylina*.

The long slender digitate branches of *S. harrisoni* are marked by more or less regularly spaced constrictions and expansions at intervals of 7 to 10 mm. These are very apparent in longitudinal sections (pl. 89, fig. 2; 2; and Gregory, 1929, pl. 8, fig. 1), in which the thin, darker outer zone of the corallum at the expansions is seen to continue internally and arch upwards, completing the curve of the expanded exterior. Between these darker concentric zones are lighter ones. In the dark layers the skeletal elements are all lighter in structure; in the lighter layers they are heavier due to stereome. This alternation of skeletal deposition is at once suggestive of seasonal variation of ecologic factors affecting growth, and that the annual growth rate of this species was 7 to 10 mm. Of the other corals associated with *S. harrisoni*, *Myriophyllia trinitatis* and *Calamophyllia sandbergeri*, corallites of the latter have expansions about 12–15 mm. apart. The specimens of *M. trinitatis* are not sufficiently complete or well-preserved to show the presence or absence of growth variations.

Genus STYLANGIA de Fromentel, 1847

STYLANGIA LADDI Wells

Plate 80, figure 5

Stylangia laddi WELLS, 1944, Jour. Paleontology, 18, p. 437, pl. 70, figs. 7–9; pl. 71, fig. 1.,

Occurrence and material.—Lower Cretaceous, Baccus River, Charuma area, Central Range, Trinidad: USNM No. 104250; Piparo River: USNM No. 104251. Upper Barranquin formation (upper Aptian), northeastern Venezuela.

Remarks.—In the boulder from Baccus River are several small worn fragments which show little but rough cross sections of corallites. These have an internal diameter of 1 to 1.5 mm., and show two complete cycles of septa, with parts of the third, arranged 6/6/2. The small styliform columella is apparently reached by only three septa, but the attachment of the septa to the columella is by alternate trabeculae from septum to septum of the first cycle. The peritheca is solid between the protuberant corallites, which are about 1.5 mm. apart. None of the fragments is complete enough to determine the presence of the characteristic stylangid unilateral mode of growth. The specimens seem to represent *S. laddi;* at any rate, they are not *Enallhelia occidentalis* Wells, *Stylosmilia gregorii* Wells, or *Stylina harrisoni* (Gregory), corals with similar internal structures.

Another small fragment found in a Piparo River block encountered in cutting for other corals, shows a vertical slice lengthwise through a worn branch tip, and shows clearly the unilateral branching.

Genus MYRIOPHYLLIA d'Orbigny, 1849

MYRIOPHYLLIA CUYLERI (Wells)

Plate 89, figure 6.

Eugyra cuyleri WELLS, 1932, Jour. Paleontology, 6, p. 237, pl. 35, fig. 4.

Myriophyllia cuyleri WELLS, 1944, Jour. Paleontology, 18, p. 436.

Occurrence and material.—Lower Cretaceous, Piparo River, Central Range, Trinidad: USNM No. 104252. Also: Lower Glen Rose formation (lower Albian), central Texas.

Remarks.—Worn fragments of thick, laminar colonies are referred to this species. The valleys are narrow, rarely more than 2 mm. wide, there is no columella, and the

septa are nearly equal, thick, short, numbering 9 or 10 in 5 mm., with tabular dissepiments about 3 in 2 mm. These are the characters of *M. cuyleri*, confirmed by comparison with thin sections of the Texas species.

M. borrachensis Wells (1944, p. 436, pl. 70, figs. 2, 3) from the Lower Cretaceous of northeastern Venezuela, is a very closely related species, differing only in the presence of a very weakly developed columella. More material may show the identity of these two forms.

MYRIOPHYLLIA TRINITATIS Wells, n. sp.
Plate 89, figure 7; Plate 90, figure 3a

Description.—Corallum explanate, upper surface strongly convex, composed of meandrine corallite series with directly fused walls. Series short, irregular, rarely more than 6 or 8 mm. in length, from 1 to 1.75 mm. wide, commonly nearer 1 mm. Septa thin but proportionally fairly stout, 15 to 20 in 5 mm., tending to alternate in length and thickness, larger ones extending almost to the axis of the valleys, the shorter ones about halfway. Monocentric corallites uncommon, nearly 2 mm. in diameter, with 12–15 septa. Columella wholly absent. Endotheca tabular, regularly developed, with about 6 tabulae in 2 mm.

Occurrence and material.—Lower Cretaceous, Swiss River, Central Range, Trinidad: holotype USNM No. 104253; Piparo River: USNM No. 104254.

Remarks.—This species is distinguished from other American Lower Cretaceous forms by its much narrower valleys, the only one approaching it in this respect being *M.* sp. *aff. M. neocomiensis* (de Fromental) (Felix, 1891, p. 159) from the Tehuacan region of Southern Mexico. In the Mexican coral the valleys have a slightly greater maximum width with proportionally more numerous and definitely alternating septa. *M. pusilla* (Koba) (1886, p. 22, pl. 8, figs. 8–9) from the Neocomian of Morteau (Doubs) has even narrower (1 mm.) valleys and more closely-spaced septa (30 in 5 mm.). Two other species possibly allied to *M. trinitatis* are *M. continua* (Blanckenhorn) (Felix, 1909, p. 173, pl. 7, fig. 6) from the Syrian Cenomanian, which has series 1.2–2.5 mm. wide with septa 12–15 per 5 mm. and *M. bernardi* (Prever) (1909, p. 81, pl. 3, figs. 18, 18a) from the Aptian of Capri, with valleys 1.25–2.25 mm. and septa 14–16 per 5 mm. The latter species has recently been reported from Greece (Hackemesser, 1936, p. 10, pl. 1, figs. 1, 2) in beds presumed to be Middle Cretaceous (Cenomanian) in age. Both lack columellae and probably form a genetic group with *M. trinitatis*, the latter being distinguished by its more or less discontinuous and slightly narrower series and proportionally slightly more septa *M. digitata* (Koby) (1898, p. 21, pl. 8, figs. 4–7) from the Urgonian at Reignier, has irregular series, but wider (2–3 mm.) valleys and fewer septa (12 per 5 mm.)

Family CALAMOPHYLLIIDAE
Genus CALAMOPHYLLIA de Blainville, 1830
CALAMOPHYLLIA SANDBERGERI (Felix)
Plate 89, figure 3a, Plate 90, figures 1, 2

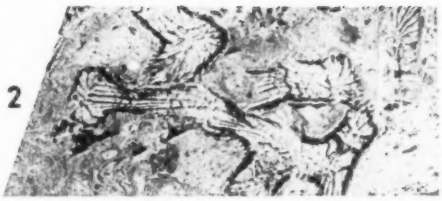
Calamophyllia sandbergeri FELIX, 1891, Paleontographica, 37, p. 153, pl. 22, fig. 9.
Diplarea venezuelensis GREGORY, 1927, Geol. Mag., vol. 64, p. 441, pl. 13, figs. 1a (and 1b?)
Calamophyllia sandbergeri WELLS, 1944, Jour. Paleontology, 18, p. 438, pl. 71, figs. 2, 3; pl. 74, figs. 1, 5.

Occurrence and material.—Lower Cretaceous, Swiss River, Central Range, Trinidad: One large colony USNM No. 104255, and several fragments mingled with the large colony (104249) of *Stylina harrisoni*, Cush River; Piparo River: with holotype of *Thamnasteria? piparensis*, USNM No. 104257. Also: Aptian (Barremian?), Tehuacan region, southern Mexico; Upper Barran-

EXPLANATION OF PLATE 91

1, 2—*Elasmophyllia tolmachoffana* Wells (USNM 104263), Piparo River. Sections of fragments of same colony in block, ×1¼. (p. 616)
3–5—*Microsolena kugleri* Wells, n. sp., holotype (USNM 104260), Piparo River. *3, 4*, trans. and vert. sections, ×6; *5*, worn surface of fragment, ×2¼. (p. 615)
6, 7—*Microsolena delicatula* Wells, n. sp., holotype (USNM 104261), Baccus River. Trans. and vert. sections, ×2¼. (p. 615)
8, 9—*Montlivaltia* sp. cf. *M. burckhardti* Wells (USNM 104262), Baccus River. *8*, trans. section, ×1; *9*, trans. section showing traces of epitheca, ×2¼. (p. 616)

1



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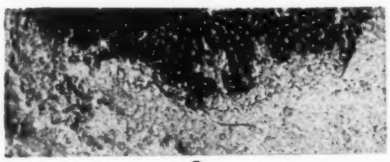

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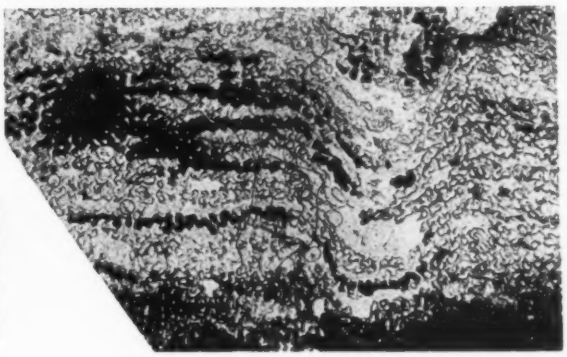

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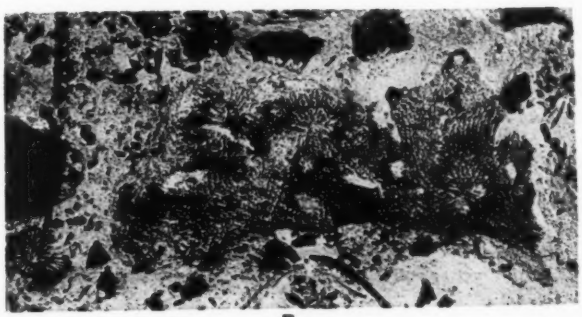

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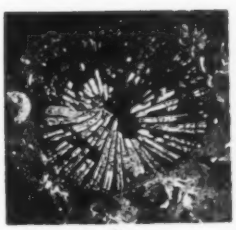

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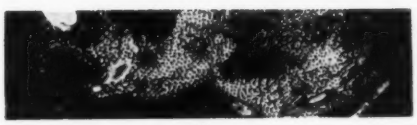

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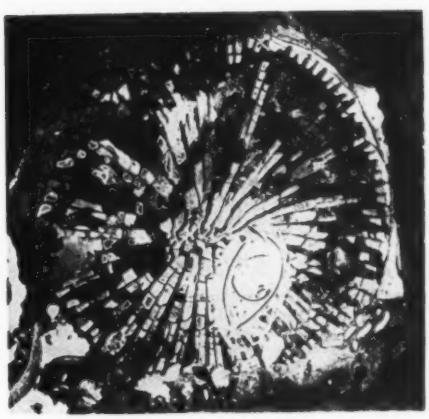

9

Wells, Lower Cretaceous Corals from Trinidad

quin formation, State of Sucre, northeastern Venezuela.

Remarks.—Since this species has been redescribed by the writer in the paper cited above, it will be summarily dealt with here.

The corallum is phaceloid, composed of upright, parallel branches, 5–8 mm. in diameter, 2–5 mm. distant, externally costate. Septa 40–50 in number, slightly alternating in size, irregularly imperforate, the larger ones reaching the loose, trabecular columella. Synapticulotheca thin, irregularly perforate, with equal costae.

Allied species are *C. compressa* d'Orbigny (Koby, 1898, p. 39, figs. 2–4) from the Urgonian of France, *C. zumenoffeni* (Felix) (1909, p. 171, pl. 7, fig. 6) from the Cenomanian of Syria, which has corallites 4–7 mm. with 62–68 septa; *C. baali* (Felix) (1909, p. 171, pl. 5, figs. 6, 7), from the same beds, inadequately described but evidently very close to *C. zumenoffeni* except for its very strongly compressed corallites. *C.? corymbosa* Koby (1898, p. 41, pl. 9, fig. 1) from the Urgonian of Morteau has very much larger corallites and a growth habit suggestive of *Latomeandra* rather than *Calamophyllia*. *C. stutzi* Koby (1898, p. 40, pl. 7, fig. 1) from the Swiss Urgonian, like *C. compressa*, is much like *C. sandbergeri*, but both species have proportionally more (60–70) septa. The coral identified by Hackemesser from the Middle (?) Cretaceous of central Greece (1936, p. 38, pl. 5, fig. 3) as *Cladocora jamaicaensis* Vaughan 1899, of the Jamaican Upper Cretaceous, is not this species but a *Calamophyllia* with corallites 4–6.5 mm. in diameter and 32–48 septa.

Genus OVALASTREA d'Orbigny, 1849

OVALASTREA RUTSCHI Wells, n. sp.

Plate 90, figures 3, 4

Description.—Corallum small, nodular, presumably attached by a small base. Diameter of type, 25 mm. Colony formation by intratentacular budding, permanent condition of corallites monocentric, forming plocoid clumps in which the corallites are united nearly to their summits by costae and exotheca. Corallite walls synapticulothecate, costate. Calices sometimes circular (2 mm. in diam., with 30 septa), but usually oval with diameters 2×2.5 mm. (31 septa) to 3×3.5 mm. (42 septa) rarely protuberant more than 1 mm. and either practically in contact with each other or with 1 mm. interspaces. Septa calamophylliid, perforated internally, arranged fundamentally in three complete, regularly uniting cycles, with the fourth cycle developed in some systems, but commonly the whole arrangement is disturbed as a result of budding. Columella trabecular, formed by interlacing of inward-projecting trabeculae from the inner ends of the 12 septa of the first two cycles. Costae high, rounded, slightly broader than intercostal spaces, approximately equal.

Occurrence and material.—Lower Cretaceous, Swiss River, Central Range, Trinidad: one specimen, the holotype, in same small block with holotype of *Myriophyllia trinitatis*, USNM No. 104253; Piparo River, scattered fragments in blocks.

Remarks.—In addition to the figured holotype, the piece containing it also shows parts of smaller, less mature colonies whose growth form seems to have been turbinate with relatively few, more protuberant (2 mm.) corallites.

The corallites of this species are considerably smaller than usual in this genus, and the number of septa is correspondingly fewer. In most species corallites are at least 4 mm. in diameter, the septa 60 or more and less regularly arranged. *O. baumbergeri* (Koby) (1898, p. 52, pl. 10, figs. 5, 5a), from the Valanginian, and *G. lorioli* (Koby) (1898, p. 53, pl. 10, figs. 6, 7), from the Urgonian, approach *O. rutschi*, but the least diameter of the corallites is 3 mm. *O. fredericksburgensis* Wells (1933, p. 98, pl. 8, figs. 15–18) from the Albian of central Texas, also may be allied, but, like the European species just mentioned, has somewhat larger corallites and more septa.

Genus PROTOSERIS Milne Edwards & Haime, 1851

PROTOSERIS? INCERTA Wells, n. sp.

Plate 90 figures. 7–11

Description.—Corallum fixed, expanding rapidly from a monocentric pedunculate base; upper surface apparently flat. Exterior non-epithecate, the common septothecate wall covered with stout, equal costae. Colony formation by intratentacular circumoral budding, the first series of centers about .6 mm. from the parent center, the

second series somewhat irregular, from 4 to 8 mm. from the first; succeeding series irregular. Septa thin, subequal, almost completely imperforate, composed of simple trabeculae, laterally strongly ridged. In the monocentric initial stage there are about 80 septa, more or less regularly arranged with the higher cycles fused to the lower, and with about 12 septa extending to the axis where their inner trabeculae form a well-defined paliform ring, united by synapticulae, in the midst of which is a papillar columella. In secondary centers about 12 septa reach the columella. From the initial center the septo-costae radiate towards the margins, soon becoming parallel, spaced 12–16 per 5 mm., measured tangentially. At secondary centers they curve inwards abruptly. Subtabular or subcystiform dissepiments abundant, about 6 per mm.

Occurrence and material.—Lower Cretaceous, Baccus River, Central Range, Trinidad: holotype USNM No. 104256.

Remarks.—Several specimens of this coral were found in the Baccus River block. One is a young corallum (pl. 90, figs. 7, 8) with a monocentric base about 8 mm. in diameter, and a diameter of 24 mm. at a point 6 mm. above the base, at which level there is one secondary ring of centers and scattered tertiary and quaternary centers. A fragment of a much larger colony (pl. 90, fig. 11) measures 77 mm. radially but does not include the initial center. There are no traces of collines in these specimens but better preserved material showing the calicular surface might reveal them.

The septal structure, fenestrate with very few perforations and simple trabeculae, indicates the calamophylliid relations of this coral. The growth-form, vasiform with thin, expanded horizontal margins, produced by early circumoral budding succeeded by irregular development of marginal centers, is closest to *Protoseris*. The septal structure also is exactly like that of the genotype, *P. waltoni* E. & H. In *Protoseris*, however, the margins of the colony are characteristically contorted folia marked by collines resulting from polystomodeal budding. The only other calamophylliid pertinent here is *Periseris*, but in this genus the corallites are more individualized, well-defined, with short septocostae, and show a close relationship to *Isastrea*. It is possible that a new genus (homologous with *Dimorphoseris*, *Dimorpharaea*, and *Dimorphastrea*) is involved here, which would also include *Thamnastraea xipei* Felix (1891, p. 144, pl. 24, fig. 6), and *T. barcenai* Felix (1891, p. 144, pl. 23, fig. 7, 7a; pl. 22, fig. 3) of the Mexican Neocomian, but until better material of the present species is available and Felix' material can be restudied, it is unnamed.

Both *T. xipei* and *T. barcenai* differ from *P.? incerta* by their strongly alternating septa, more septa reaching the axis of the centers, and somewhat more distant centers. With the exception of *Protoseris cretacea* Felix (1903, p. 228, pl. 20, fig. 11–13), from the Gosau Upper Cretaceous, this is the only Cretaceous species referred to *Protoseris*.

Family THAMNASTERIIDAE

Genus THAMNASTERIA Lesauvage, 1823

THAMNASTERIA? PIPARENSIS Wells, n. sp.

Plate 90, figures 5, 6

Description.—Corallum apparently forming laminae about 5 mm. thick, with more or less even calicular surface and costate, non-epithecate lower surface. Centers arranged roughly parallel in irregular series separated by collines. The series are 2.5–3 mm. wide; within them the centers are about 2 mm. apart. Internally the collines are represented by synapticulothecal thickenings between the series. Septa and septocostae thin, parallel, equal, about 30 per 5 mm., mostly imperforate. In vertical tangential section the fenestrate structure can be seen, and a few septa near the axis may be openly fenestrate. At the centers about 12 septa bend toward the axis, which is marked by two or three columellar papillae. Synapticulae weakly developed.

Occurrence and material.—Lower Cretaceous, Piparo River, Central Range, Trinidad: holotype, USNM No. 104257.

Remarks.—This species is based upon a worn fragment about 30 mm. long, in which the structure is well preserved, but the form of the corallum is uncertain. The series may have been radiating or concentric—probably the latter in view of their lying across the direction of the radiating septocostae—and the general form may have been similar to *Pachyseris*, but with less prominent and less regular collines.

The reference to *Thamnasteria* is tentative, pending further knowledge of the

corallite series. It is likely that a new thamnasterioid genus is represented, homologous with the siderastreid *Pironastrea* and the agariciid *Pachyseris*.

Family LEPTOPHYLLIIDAE
Genus SYNASTREA Milne Edwards & Haime, 1848
SYNASTREA sp. cf. S. CRESPOI (Felix)
Plate 90, figure 12

Thamnastraea crespoi FELIX, 1891, Palaeontographica, vol. 37, p. 146, pl. 22, fig. 5.

Occurrence and material.—Lower Cretaceous, Piparo River, Central Range, Trinidad: USNM No. 104258; Baccus River: USNM No. 104259. Also: Lower Cretaceous (upper Aptian), Tehuacan region, southern Mexico (Felix, 1891).

Remarks.—Two worn fragments of a leptophylliid coral may represent Felix' species. The corallites are thamnasterioid with wholly confluent thick septa, numbering about 30 per center. The centers are 5 to 8 mm. apart. About 12 septa extend to the corallite centers and join a weak columella formed by a few trabecular rods. Higher cycle septa are perforate internally. Dissepiments very thin and fine, but abundant.

All the features noted above correspond with Felix' description, but identity with his species is uncertain until the Mexican Lower Cretaceous corals can be restudied.

Family MICROSOLENIDAE
Genus MICROSOLENA Lamourouz, 1821
MICROSOLENA KUGLERI Wells, n. sp.
Plate 91, figures 3–5

Description.—Form of corallum uncertain, but probably nodular-massive, at least up to 40 mm. high and 100 mm. broad. Corallites irregularly scattered, undifferentiated, superficial but with well-defined fossette, centers 3–5 mm. apart. No corallite walls or boundaries, the septocostae being directly confluent between centers. Septa equal in thickness, uniting by their inner ends cyclically, fenestrate, highly perforate, all structures being thin and small. About 12 septa extend to the corallite axis; about 1 mm. radially from the axis the septa number about 36; midway between centers there are 5 septocostae per millimeter. In vertical section the trabecular centers number about 5 per millimeter. Columella very weak and small, formed by several trabeculae from inner septal ends.

Occurrence and material.—Lower Cretaceous, Piparo River, Central Range, Trinidad: holotype, USNM No. 104260.

Remarks.—The calicular surface cannot be seen on the specimens, being worn away, but there is no suggestion in the vertical sections that the calices are protuberant, as in *Polyphylloseris*.

In the section showing *Synastrea* sp. cf. *S. crespoi* (pl. 90, fig. 12) is a vertical section through the center of a small monocentric turbinate microsolenid which probably also belongs to *M. kugleri*.

Two other species of this genus are known from the American Cretaceous: *M. texana* Wells (1932, p. 252, pl. 35, fig. 2; pl. 37, fig. 5) from the lower Glen Rose formation of Texas, which has centers nearly twice as far apart as *M. kugleri*, and *M. williamsonensis* Wells (1944, p. 100, pl. 20) from the Buda limestone (Cenomanian) of central Texas, in which the centers are very closely spaced about half as far apart as in *M. kugleri*. *M. guttata* Koby (1897, p. 83, pl. 21, figs. 1, 2) from the Urgonian at Morteau (Doubs) is very closely related, the only observable difference being the more widely spaced (5–6 mm.) centers.

MICROSOLENA DELICATULA Wells, n. sp.
Plate 91, figures 6, 7

Description.—Form of corallum uncertain apparently an expanded, slightly convex lamina. Centers very small, about 1 mm., 2–5 mm. apart, with 6–8 septa bending to meet the columellar papillae. Septa and septocostae highly fenestrate and perforate, about 20–25 per 5 mm., unequal, uniting to some extent at centers. External surfaces unknown.

Occurrence and material.—Lower Cretaceous, Baccus River, Charuma area, Central Range, Trinidad: holotype, USNM No. 104261.

Remarks.—This delicate little microsolenid is obviously closely allied to *M. williamsonensis* Wells (1944, p. 100, pl. 30) from the Buda limestone of Texas, the main distinction being the finer, smaller, equal septa (30 per 5 mm.) of the Texas species. The Trinidad material is very imperfect, the holotype being a small fragment 30 mm. by 7 mm.

Family MONTLIVALTIIDAE
Subfamily MONTLIVALTIINAE
Genus MONTLIVALTIA Lamouroux, 1821
MONTLIVALTIA sp. cf. M. BURCKHARDTI Wells
Plate 91, figures 8, 9

Montlivaltia burckhardti WELLS, 1946, Jour. Paleontology, 20, p. 4, pl. 1, fig. 5; pl. 2, figs. 7–14.

Occurrence and material.—Lower Cretaceous, Baccus River, Charuma area, Central Range, Trinidad: three specimens, USNM No. 104262. Also; Hauterivian, Coahuila, northern Mexico.

Remarks.—In the large boulder from the side branch of Baccus River are several badly worn specimens of a *Montlivaltia* which are seemingly indistinguishable from *M. burckhardti*, so far as cross-sectional dimensions and number and arrangement of septa are concerned:

Specimen	Dimensions	Septa
1	25×26 mm.	ca. 100
2	20×22 mm.	ca. 125
3	26×27 mm.	ca. 110

One specimen shows a natural longitudinal section wherein can be seen the usual dissepiments of the genus, the dentate septal margins, and turbinate growth-form.

Subfamily LASMOGYRINAE
Genus ELASMOPHYLLIA d'Achiardi, 1875
ELASMOPHYLLIA TOLMACHOFFANA Wells
Plate 91, figures 1, 2

Aplosmilia ? tolmachoffana WELLS, 1932, Jour. Paleontology, 6, p. 334, pl. 30, fig. 2; pl. 31, fig. 2.

Elasmophyllia tolmachoffana WELLS, 1944, Jour. Paleontology, 18, p. 442, pl. 72, figs. 6–8.

Occurrence and material.—Lower Cretaceous, Piparo River, Central Range, Trinidad: USNM No. 104263. *Also:* Lower Glen Rose formation (lower Albian), Comal and Hays Cos., central Texas; Upper Barranquin formation, State of Sucre, northeastern Venezuela.

Remarks.—Sections of corallites of this species were found in one of the Piparo River blocks. They show a wide variation in corallite size—from 4 to 10 mm. The smaller ones are young buds; budding evidently was rapid in this species, often at intervals of as little as 5 mm., the young corallites becoming separated rapidly, but united to the parent by lamellar linkage until individualized. In early stages of development, the columella is attached to a major septum, from which it was derived, but later in most corallites it is quite independent, well within the circle of the inner ends of the septa and connected to them only by sparse subtabular endotheca. The epitheca, first noted in the Venezuelan material, is occasionally preserved in that from Trinidad.

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JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 5, PP. 617–623, 11 TEXT FIGS., SEPTEMBER 1948

NEW PENNSYLVANIAN DIBUNOPHYLLID CORALS

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ABSTRACT—Two new dibunophyllid corals are described from Pennsylvanian rocks of Oklahoma and Kansas. *Dibunophyllum moorei*, n. sp., occurs abundantly in the Oologah formation, Desmoinesian series, and *D. exigum*, n. sp., is from the Dover limestone, Virgilian series.

INTRODUCTION

RECENT studies on American late Paleozoic coral faunas have indicated the presence of many distinctive types of corals in Pennsylvanian rocks. The usefulness of these fossils to stratigraphic paleontology, however, depends in part on the relative number of described forms and on the adequate recognition of small but characteristic differences. Dibunophyllid corals have been identified throughout the Pennsylvanian section in the Mid-Continent area, but only locally do they occur in abundance (Jeffords, 1948). Although comprehensive studies on this group of corals are incomplete, two of the more characteristic species are described at this time.

Dibunophyllum occurs abundantly in some rocks of Mississippian age throughout the world, and a few Pennsylvanian and Permian corals from widely scattered localities have been assigned to this genus. In North America dibunophyllid corals seem to have been referred to *Axophyllum* in the early studies, and most subsequent workers adopted a very broad interpretation of the species. Inasmuch as specific characters were based largely on external form, which varies notably even for specimens from a single locality, these Pennsylvanian dibunophyllids were considered to have relatively long ranges. Newell (1935) recognized and described a new species from the Stanton limestone of southeastern Kansas, and *D. ? inauditum* Moore and Jeffords (1945) is known from the Hale formation. On the whole however, American Pennsylvanian dibunophyllid corals have received little attention.

Dibunophyllum occurs in the northern Mid-Continent area as a minor part of the faunas of a large proportion of the Pennsylvania formations, but only locally in limestones and calcareous shales are these corals as common as the lophophyllidid and caninid corals.

Morphologic terms used in the following discussion and the methods for preparation of the illustrations are described in earlier papers (Moore and Jeffords, 1945; Jeffords, 1947). The type and figured specimens of the two species here described are in the paleontological collections of the University of Kansas.

Grateful acknowledgment is made to R. C. Moore of the University of Kansas for making available for study specimens in the collection of the Kansas Geological Survey and for equipment used in preparation of some of the material. L. R. Laudon, also of the University of Kansas, generously donated an excellent collection of corals from the Oologah formation.

Family CLISIOPHYLLIDAE Thomson and Nicholson, 1876

Genus DIBUNOPHYLLUM Thomson and Nicholson, 1876

Solitary or more rarely loosely joined corallites having a well-developed open column and peripheral dissepimental zone are included in this genus. Immature portions of the corallites are conical in shape whereas the upper mature parts commonly are cylindrical. The theca, which is thin, is marked externally by fine growth lines and low wrinkles; periodic constrictions due to rejuvenation may occur also, Most of the specimens seem to be solitary, but one or more daughter corallites may develop from a mature calyx in some species.

The corallites are divisible internally into a peripheral dissepimental zone, intermediate tabulate zone, and column. An inner wall formed by the thickening of the innermost dissepiments may separate the dissepi-

mental and tabulate regions. Major septa are long, mostly of uniform length, and somewhat crooked and thin within the dissepimental band. They do not become lonsdaleoid, however. Minor septa are short or rudimentary. An inconspicuous cardinal fossula is recognizable commonly, but alar pseudofossulae are inconspicuous or lacking. The axial column comprises a median lamella in the plane of the counter-cardinal septa, vertical radiating lamellae that join the median lamella at different points, and steeply inclined inner portions of the tabulae. In transverse section this column has a characteristic cobweb-like appearance and typically the elements of the column do not appear twisted. Anastomosing tabulae rise from the peripheral dissepimental zone to the column.

Genotype: *Dibunophyllum muirheadi* Thomson and Nicholson, Lower Carboniferous, Scotland.

Discussion.—This genus may be distinguished from *Clisiophyllum* Dana (1846, p. 187) by the intersection of radiating lamellae with the median lamella in the column at more or less regular intervals, and not at a single point. *Neokoninckophyllum* Fomichev (1939, p. 58) generally resembles *Dibunophyllum*, but the column is not as well defined in transverse sections and the median lamella is not prominent. *Arachnolasma* Grabau (1922, p. 59) from Lower Carboniferous rocks of South China and *Arachnophyllum* Smyth (1915, p. 558; not Dana, 1846) from the Lower Carboniferous of Ireland seem to be junior synonyms of *Dibunophyllum*. Hill (1938) has concluded that clisiophyllid genera described from Lower Carboniferous rocks of Scotland as *Rodophyllum* Thomson (1874), *Aspidiophyllum* Thompson (1875), *Kurnatiophyllum* Thomson (1875a), *Albertia* Thomson (1878), *Histiophyllum* Thomson (1879), and *Centrephyllum* Thomson (1880) are synonymous with *Dibunophyllum*. Several of these names have priority over *Dibunophyllum* but published descriptions and illustrations of the genotypes of these genera suggest that some, at least, may comprise corals differing from *Dibunophyllum*. Accordingly, decision as to replacement of *Dibunophyllum* by a prior name is deferred at this time. *Dibunophyllum* has been interpreted to differ from *Rodophyllum* in the presence of distinct lamellae in the column (Moore and Jeffords, 1945, p. 153). If the distinction between these two genera is not justified, however, *Rodophyllum* will become the valid name.

American Pennsylvanian corals that resemble *Dibunophyllum* in external form and characters visible in the calyx have been described as *Axophyllum rude* White and St. John (1867, p. 115), *A. infundibulum* Worthen and Meek (1875, p. 525), and *A. cylindricum* Girty (1915, p. 310) The genus *Axophyllum* was introduced in 1850 by Edwards and Haime to include solitary corals that have a peripheral dissepimental zone, and a more or less open column. Syntypes of *A. expansum* Edwards and Haime (1850), which is the genotype, seem not to have been sectioned, however, so that critical structural features are mostly unknown. Smith and Hill, after examination of these syntypes, differ in their tentative conclusions regarding placement of the species but indicate the doubtful nature of the genus (Lang, Smith, and Thomas, 1940, pp. 25–26). According to Smith these specimens may be isolated corallites of *Lonsdaleia crassiconus* McCoy, but Hill considers it probable that *Axophyllum* is synonymous with *Carcinophyllum* Thomson and Nicholson (1876a). Accordingly, *Axophyllum* seems to have no basis for recognition at this time. The lack of adequate data on internal structures of the American species referred to *Axophyllum* precludes positive placement, but probably most of them should be rereferred to *Dibunophyllum*. ?*Axophyllum alleni* Rowley (1901, p. 349), however, seems to be more closely allied to *Aulophyllum* Edwards and Haime (1850) on the basis of sectioned corals that are similar to *A.? alleni* in size, shape, features of the calyx, and stratigraphic occurrence.

Occurrence.—Mississippian (Lower Carboniferous) to Permian of Europe, Asia, and North America.

Dibunophyllum moorei
Jeffords, n. sp.
Text figures 3–11

This species consists of solitary corallites that vary from low broadly conical to more elongate forms. The apex commonly is flattened or thickened on one side to provide

a strong base for attachment. The theca is thin and bears conspicuous growth lines and numerous moderately sharp wrinkles that indicate stages of rejuvenation. Longitudinal markings are absent on unweathered specimens, although a groove and ridge pattern is visible where the theca has been worn away. The calyx is depressed notably within the peripheral dissepimental zone, and it contains at the axis a relatively large laterally compressed column. Major septa are conspicuous in well preserved calices, but the presence of dissepiments and minor septa is commonly concealed. Maximum observed diameters at the calyx range to 31 mm, and the maximum observed height of available corallites is 41.3 mm.

There are about 30 long major septa in the mature portions of the corallites, and about 20 septa are present commonly within a few millimeters of the apex. These septa are thin within the dissepimental zone but thicken abruptly as they enter the intermediate tabular zone. The counter septum may be long and attached to the median lamella, the cardinal septum is not notably shortened, and other major septa are mostly of uniform length. Minor septa are confined to the peripheral dissepimental zone. Insertion of septa occurs so rapidly in the youthful stage that alar pseudofossulae are not identified.

Dissepiments occur in a peripheral band that is slightly less than one-third of the radius in width. They are mostly uniform in size, slope downward steeply, and occur in transverse sections as straight or curved bars between adjacent septa. An inner wall at the junction of the dissepimental and tabulate zones is poorly developed in this species. The tabulae, as seen in longitudinal section, comprise closely crowded anastomosing structures that rise steeply toward the column. The axial column has a prominent and slightly thickened median lamella and several radiating lamellae that meet the median lamella at separate points. In transverse sections of the youthful portions of the corallites, these lamellae seem to be attenuate extensions of some of the major septa, but they comprise separate structures in the mature regions. Numerous closely spaced and nearly vertical tabulae or tabellae intersect the vertical lamellae in the column to give a distinct web-like pattern to the column.

Discussion.—Corals included in this species are distinguished chiefly by the well-developed weblike appearance of the column in transverse section, weak inner wall, and well defined median lamella. This species is separated from *D. exigum*, n. sp., by the greater number of septa in mature stages and the minor occurrence of stereoplasm. *D. moorei* is distinguished from *D. valeriae* Newell (1935, p. 343) by the more conical form of the corallite, the strongly marked median lamella, and the relatively long major septa as seen in transverse section.

Examination of the calices of numerous well-preserved examples of this species indicates that in *Dibunophyllum*, as in several other rugose genera, the appearance of the calyx may be misleading. Commonly, the inner wall, minor septa, and dissepimental zone are not recognizable, and the column may seem essentially solid.

This species is named for Dr. R. C. Moore, of the University of Kansas, who has given valued counsel and guidance in investigations of Pennsylvanian corals.

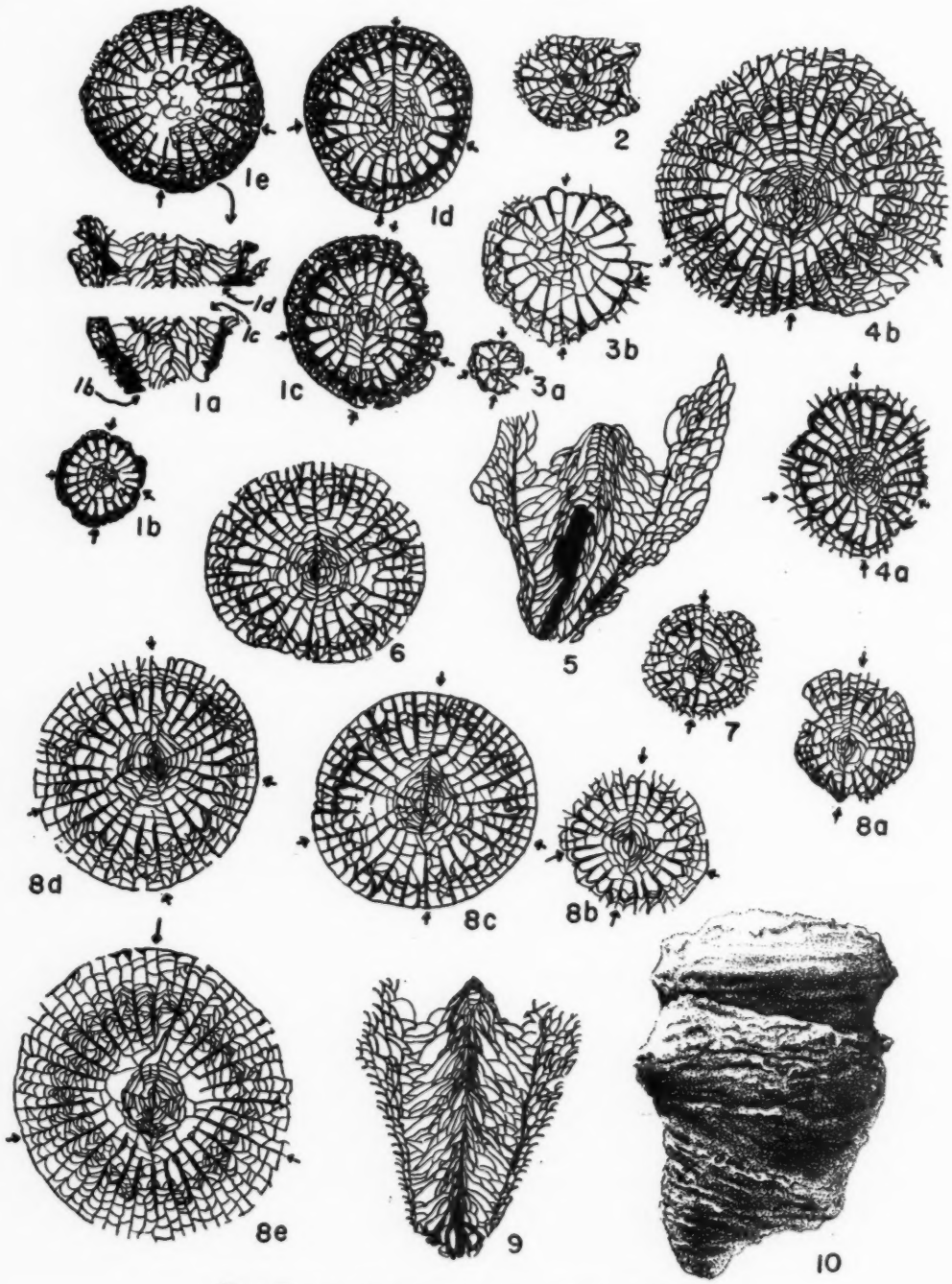
Occurrence.—Oologah formation Marmaton group, Desmoinesian series, Pennsylvanian (Upper Carboniferous). The specimens were collected by L. R. Laudon, R. C. Moore, J. M. Jewett, and R. M. Jeffords at Garnett Quarry, 7 miles northeast of Tulsa, Rogers County, Oklahoma.

Material studied.—About 125 well preserved specimens of this species were available for study, and 18 corallites were sectioned. *Lophamplexus brevifolius* Jeffords (1947, p. 66), *Stereostylus* sp., and *Pseudozaphrentoides* sp. occur associated with this coral.

Type.—University of Kansas no. 1053–24g from Garnett Quarry, northeast of Tulsa, Oklahoma.

DIBUNOPHYLLUM EXIGUM
Jeffords, n. sp.
Text figures 1–2, 11

Solitary small to medium-sized slightly curved corallites having a conical to conicocylindrical form comprise this species. The moderately deep calyx has a flattened rim underlain by the peripheral dissepimental zone and a low narrowly compressed column



TEXT FIGS. *1–10*—See opposite page for description.

within the inner depression. Transverse markings on the theca consist of numerous fine growth lines and low wrinkles; septal grooves are lacking. A down-arched lateral extension close to the apex of most corallites provided a base for attachment on a curved surface. The specimens commonly are about 13.5 mm. in height and 12 mm. in diameter at the calyx. One incomplete corallite that shows several cycles of rejuvenation reaches a length of 45 mm.

Long major septa reach from the theca to the outer edge of the column. They are thin within the dissepimental zone, thicken greatly at the inner edge of this zone, and thin out as they approach the column. The counter septum is long and reaches the median lamella; other major septa are approximately equal in length. About 24 major septa occur in the mature portions of the corallites, and the rate of septal insertion is very rapid in youthful stages. Minor septa are developed as inconspicuous structures in the dissepimental zone. Small closely spaced dissepiments occur as a peripheral band which increases in thickness upward toward the calyx. The innermost dissepiments are thickened notably by stereoplasm to form a distinct inner wall. Numerous closely spaced anastomosing tabulae rise gently from the dissepiments to the column. In transverse sections the tabulae appear as curved bars irregularly intersecting the major septa and the lamellae of the column. A median lamella is well developed in the column along the plane of the counter-cardinal septa, but radiating lamellae are less distinct. As seen in transverse sections, the column is characterized by a large number of intercepts of tabulae and few lamellae.

Discussion.—This species is characterized by its conspicuous inner wall, thickened septa, and unusually small dissepiments. It may be distinguished from *Dibunophyllum moorei*, n. sp., by the smaller and less flaring external form, more prominent inner wall, and fewer septa in mature stages. *D. exigum* differs from *D. valeriae* Newell (1935), from the Eudora shale of southeastern Kansas, in the smaller size and in the weak development of the weblike appearance of the column in transverse sections. The conical form, smaller dissepiments, and more typical dibunophyllid column of *D. exigum* permits separation readily from *D. ?inauditum* Moore and Jeffords (1945, p. 157).

A notable feature of one specimen from the type locality is the rejuvenation which occured three times after the corallite reached a diameter of about 14 mm. The corallite, thus, comprises a series of conelike portions inserted one in another.

The lophophyllidid coral *Stereostylus per-*

All figures ×3 except as noted. Transverse sections are oriented with the cardinal septum at the bottom; identified protosepta are indicated by small arrows. The position of transverse sections is indicated on the longitudinal section by small italic figures.

Dibunophyllum exigum Jeffords, n. sp., from the Dover limestone, Wabaunsee group, Virgilian series, Upper Pennsylvanian.

FIG. *1*—Type specimen (Univ. Kansas no. 7991-21a) from 3.8 miles east of Admire Junction, Lyon County, Kansas. *a*, Longitudinal section showing small dissepiments and inner wall. *b–d*, Transverse sections showing thickened septa, inner wall, and column. *e*, Transverse section in the calyx at upper tip of the column. (p. 619)

2—Transverse section in youthful part of a corallite (Univ. Kansas no. 1284-21a) from north part of west ½ Sec. 6, T. 12 S., R. 13 E., Wabaunsee County, Kansas. (p. 619)

3a–b—Transverse sections of specimen (Univ. Kansas no. 1272-21f) from southwestern corner Sec. 30, T. 11 S., 13 E., Wabaunsee County, Kansas. (p. 619)

Dibunophyllum moorei Jeffords, n. sp., from the Oologah formation, Marmaton group, Desmoinesian series, Pennsylvanian, at Garnett Quarry, 7 miles northeast of Tulsa, Rogers County, Oklahoma. (p. 618)

4a–b—Transverse sections of specimen (Univ. Kansas no. 1053-24d).

5—Longitudinal section of the type specimen (Univ. Kansas no. 1053-24g) showing dissepimental zone, inner wall, tabulae, and column.

6—Transverse section of specimen (Univ. Kansas no. 1053c).

7—Transverse section in youthful portion of corallite (Univ. Kansas no. 1053–24c).

8a–e—Serial transverse sections of specimen (Univ. Kansas no. 1053a).

9—Longitudinal section of specimen (Univ. Kansas no. 1053–24i).

10—Side view (×2.4) of specimen (Univ. Kansas no. 1053-24h) showing numerous growth lines and wrinkles.

versus Jeffords (1947, p. 60) has been doubtfully identified from the type locality of this species, and small specimens of several ties were available for study. Six of the corallites were sectioned.

Type.—University of Kansas no. 7991-

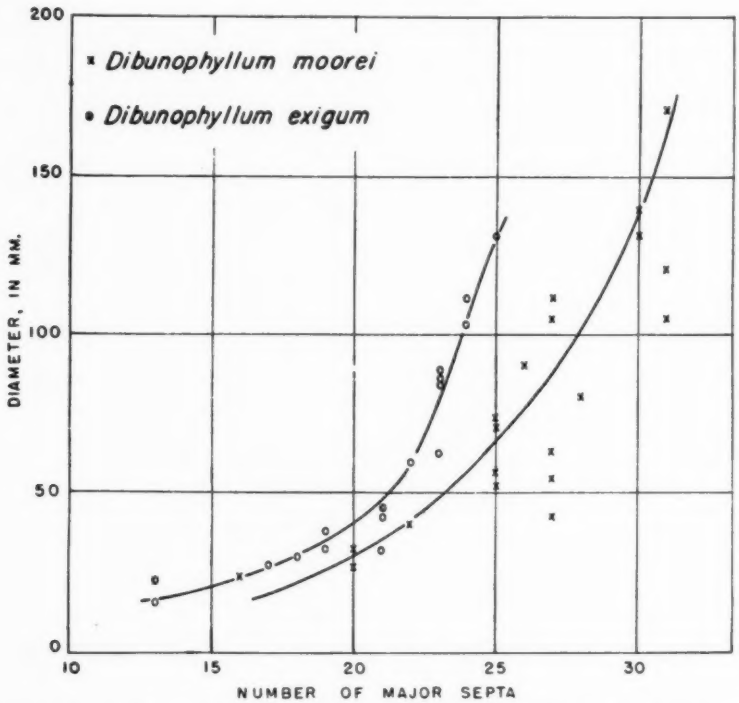


FIG. *11*—Diagram showing the relationship of the number of major septa to the diameter of the corallite in *Dibunophyllum moorei*, n. sp., and *D. exigum*, n. sp. A similar relationship for *Stereostylus lenis* is shown in Jeffords (1947, fig. 3).

ammonites, including *Goniolobocerαs welleri*, *Gastrioceras welleri*, *Gastrioceras* sp., and *Aganides*? sp., are known from the Dover limestone and the overlying shale at other localities in Kansas (Elias, 1936, p. 695).

Occurrence.—Dover limestone, Wabaunsee group, Virgilian series, Pennsylvanian (Upper Carboniferous). The type specimens were collected at an outcrop north of U. S. Highway 50N, 3.8 miles east of Admire Junction, Lyon County, Kansas. Other specimens were collected by R. G. Moss from the southwest corner Sec. 30, T. 11 S., R. 13 E. and the north part of the west ½ Sec. 6, T. 12 S., R. 13 E., Wabaunsee County, Kansas.

Material studied.—Eight moderately well preserved corallites from the type locality and several specimens from the other locali- 21a from the Dover limestone, 3.8 miles east of Admire Junction, Kansas.

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JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 5, P. 624, PL. 92, SEPTEMBER 1948

A NEW GENUS OF FORAMINIFERA FROM THE UPPER CRETACEOUS

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University of Kansas

A NEW genus of the Foraminifera has been found in the Marlbrook marl of Upper Cretaceous age in Arkansas.

The writer is grateful to Dr. Joseph A. Cushman for examining specimens of the genus and to Mrs. Don D. Hughes for making the drawings.

All types and figured specimens are deposited in the Cushman Laboratory for Foraminiferal Research, Sharon, Massachusetts.

Family GLOBIGERINIDAE
Genus BIGLOBIGERINELLA,
Lalicker, new genus

Test small, trochoid in the early stages, at least in the microspheric form, planispiral and involute; chambers in the early stages globular, in the adult stage the last-formed chambers are flattened and the last one is divided into two globular chambers, one on each side of the plane of coiling; sutures distinct, depressed; wall calcareous, perforate, with tiny short spines on the exterior; aperture consisting of a low slit-like arch at the base of each of the last chambers, usually quite indistinct.

Genotype: *Biglobigerinella multispina*, new species, Marlbrook marl, Upper Cretaceous, 8 feet above the base, 1½ miles north of Saratoga, Howard County, Arkansas.

Discussion.—The most interesting character of this genus is the development of the paired chambers, one on each side of the plane of coiling in the adult growth stage. The last chamber becomes broad and flattened before dividing along the plane of coiling into two chambers. In most specimens which have reached the adult growth stage, there is only one pair of chambers, but the next to the last chamber is usually partially divided, and the others near the end are broad and somewhat flattened.

BIGLOBIGERINELLA MULTISPINA, Lalicker, n. sp.
Plate 92, figures 1 a–c, 2a, b, 3 a–c

Test planispiral, involute, trochoid in the earliest chambers, especially in the microspheric form; chambers in the early stages globular, in the adult stage the last-formed chambers are flattened and the last one is divided into two globular chambers, one on each side of the plane of coiling; sutures distinct, depressed; wall calcareous, perforate, with tiny spines on the surface; aperture consisting of a low arch at the base of each of the last chambers, and quite indistinct.

Measurements of the type specimen are as follows: height, 0.32 mm.; maximum thickness, 0.29 mm.

Occurrence.—Marlbrook marl, Upper Cretaceous age, 8 feet above the base, 1½ miles north of Saratoga, Howard County, Arkansas.

Holotype.—Cushman Collection No. 51898.

EXPLANATION OF PLATE 92

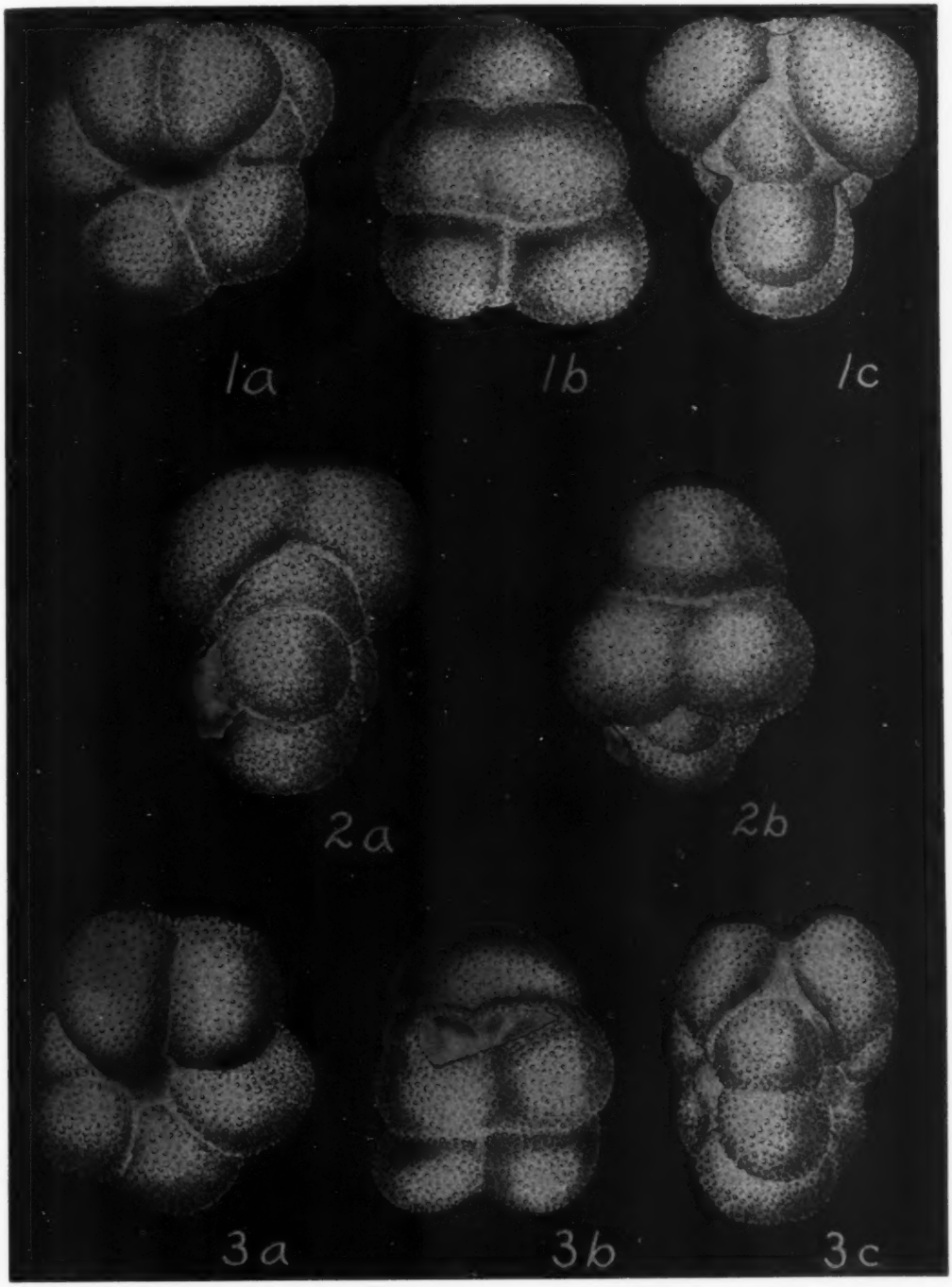
(All figures 125 times natural size)

Biglobigerinella multispina, Lalicker, n. sp., from the Marlbrook marl, north of Saratoga, Howard County, Arkansas.

FIGS. *1a–c*—Holotype, Cushman Coll. No. 51898, showing the typical development of the species. The last-formed paired chambers are completely separated and the chamber behind them is partially divided. *a*, side view, *b*, top view, and *c*, apertural view. (p. 624)

2a, b—Paratype, Cushman Coll. No. 51900, showing an immature shell in which the final chamber is only partially divided. *a*, apertural view, and *b*, top view.

3a–c—Paratype, Cushman Coll. No. 51899, showing the final paired chambers completely separated and the next earlier chamber partially divided. *a*, side view, *b*, top view, and *c*, apertural view. (p. 624)



Lalicker, New Genus of Foraminifera

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 5, PP. 625–629, 10 TEXT FIGS., SEPTEMBER 1948

THE DENTARY OF *TROÖDON*, A GENUS OF THEROPOD DINOSAURS

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ABSTRACT—An incomplete dentary, from the Upper Cretaceous of Alberta, bears teeth almost identical with the type of *Troödon formosus* Leidy. This specimen corroborates the view of C. M. Sternberg that *Troödon* is not related to *Stegoceras*, but is in fact a genus of small theropod dinosaurs.

INTRODUCTION

IN 1856 Joseph Leidy described a collection of teeth from what is now called the Judith River formation of Montana, collected by F. V. Hayden at considerable personal risk. The various genera and species erected on this material have continued to plague succeeding paleontologists with the problem of their relationship to more adequate material collected subsequently. Among these troublesome genera is *Troödon*, type *T. formosus*, based upon a single tooth (figs. 1, 2, 3) of small size, the crown being slender, compressed from side to side, acutely pointed, distinctly recurved, and with well defined denticulations on the anterior and posterior edges. Subsequently Leidy (1860) described the specimen more fully, with illustrations. He referred the genus to the varanid lizards, and many subsequent workers followed him in this reference. Lambe (1902) identified similar teeth in the "Belly River" (Oldman formation) of Alberta. Hatcher (1905) was the first to regard *Troödon* as dinosaurian, although his reference was provisional, and he made no attempt to postulate more detailed relationships.

The problem of the systematic position of *Troödon* was thought to have been settled when Gilmore (1924) described an excellent skull and incomplete skeleton from the Oldman formation, preserved in the department of Geology University of Alberta. This skull proved to incorporate the frontoparietal mass often found in the Oldman and Edmonton formations, and originally described by Lambe (1902) as *Stegoceras validus*. Gilmore concluded that the teeth in the anterior part of the jaws of this skull were sufficiently like the type of *Troödon formosus* to justify reference of *Stegoceras validus* to the same genus. This view has met with wide acceptance, and *Stegoceras*-like specimens have been described by various authors under the name of *Troödon*. The most outstanding work of this sort is the revision by Brown and Schlaikjer (1943), in which two new species are described, and a new genus of "Troödontidae" erected.

C. M. Sternberg has been dissatisfied for some years with the relegation of *Stegoceras* to synonomy with *Troödon*, as he has revealed to the writer in several conversations. His study of the question culminated in a paper (Sternberg, 1945) in which he concluded that the type of *Troödon* was a tooth fundamentally unlike any found in the *Stegoceras* dentition. He therefore reestablished *Stegoceras* as a genus, and as the family name Troödontidae was inapplicable, proposed the new family name Pachycephalosauridae, based on a very descriptive generic name proposed by Brown and Schlaikjer. Sternberg's material representing the real *Troödon* consisted only of a cast of Leidy's type, together with isolated teeth of the same sort from the Red Deer river. From these he could deduce only that *Troödon* was some sort of small theropod dinosaur. The characters which he recognized as distinguishing teeth of *Troödon* from those of *Stegoceras* were:

(a) the denticulation of the edges is not continued onto the crown as fluting;
(b) there is no enlargement of the base of the crown;
(c) the root is open and unconstricted;
(d) the oblique facet of wear is like that of theropods, and is not found in *Stegoceras* or the ornithopods generally.

To these I should add that the enamel shows a colour pattern of transverse bands, similar to those in the teeth of theropods and crocodiles.

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TEXT FIGS. *1–7*—See opposite page for description.

The publication of C. M. Sternberg's paper reminded L. Sternberg, Chief Preparator of the Royal Ontario Museum of Palaeontology, of a specimen collected in 1935 from the Oldman formation (upper Belly River series) on Red Deer River, in the vicinity of Little Sand Hills creek, Alberta. Preparation of this specimen (R. O. M. Pal. No. 1445) revealed the left dentary of a small, broad mandible (figs. 4–6), containing remnants of teeth (figs. 8–10) almost identical with the type of *Troödon*. This dentary is quite unlike that of *Stegoceras*, and shows no indication of the presence of a predentary bone.

The teeth still present are two in number, one of them set deeply in the alveolar row at about mid-length (fig. 9), The other fully exposed near the posterior end of the series (fig. 10). In addition, the second and third teeth of the series are represented by root fragments in place near the symphysis (fig. 8). The posterior teeth are those that resemble the type of *Troödon*, but are of somewhat smaller size. Like Leidy's specimen they are compressed, and distinctly recurved. The denticulations along the posterior edge are well developed, but those of the anterior edge are much weaker than in the type. There is no trace of fluting. The enamel shows a colour pattern of fine vertical lines, and transverse bands of lighter and darker brown. The teeth terminate below with no distinct root nor basal expansion to the crown. The two vestiges of anterior teeth indicate a cross section almost circular (fig. 7). The first (number 2 of the whole series) shows no vestige of serrated edges, although such may have been present higher on the missing crown. The second remnant shows a vestige of the anterior serrated edge, which is directed more towards the outer wall of the dentary than towards the anterior end. One is strongly reminded of the heterodont condition of certain theropod dinosaurs, with their blade-like posterior teeth ("*Deinodon*") and their pillar-like anterior teeth ("*Aublysodon*").

The tooth sockets (fig. 6) are formed by transverse partitions in the alveolar row. The anterior sockets are short and broad, and the first is the largest of the series. Posteriorly they become longer and more compressed, but nevertheless seem too short for the anteroposterior width of the teeth. The outer surface of the dentary (fig. 4) is broadly convex, and bears numerous pits and grooves, which are concentrated along the alveolar border, the ventral margin, and the vicinity of the symphysis. The inner surface (fig. 5) is smooth, but there is a deep, narrow Meckelian groove near the ventral margin, extending from the splenial region to a foramen at the symphysis. A similar groove occurs in the dentary of theropods, but is less incised, and is situated higher on the inner surface. The depth and position of the groove on the *Troödon* dentary suggests the corresponding feature of the crocodilian dentary, which, however, is concealed for much of its length by the splenial. The symphysis of the *Troödon* jaw is a flat surface, showing only a faint rugosity. Viewed from above it truncates the long axis of the jaw almost at right angles. Viewed from the inner side it is seen to slope sharply backward and somewhat inward. The symphysial surface is produced ventrally in the form of a bluntly pointed process, which projects below the ventral margin of the jaw. Orientating the specimen so that the symphysial plane coincides with the imaginary medial axis of the skeleton, it can be seen (fig. 7) that the complete jaw must have been

FIG. *1*—*Troödon formosus* Leidy. Holotype, tooth, Academy of Natural Sciences of Philadelphia, No. 9259; Judith River formation, Upper Cretaceous, Montana; ×6 (A. N. S. photograph). (p. 629)

2—The same, showing facet of wear; ×6.

3—The same, anterior view; ×6.

4—*Troödon* sp. Left dentary, Royal Ontario Museum of Palaetontology, No. 1445; Oldman formation, Upper Cretaceous, Alberta; external view; ×1. (p. 627)

5—The same, internal view; ×1.

6—The same, alveolar view; ×1.

7—The same, restoration of mandible by adding reversed outline to dorsal view of left dentary; ×1.

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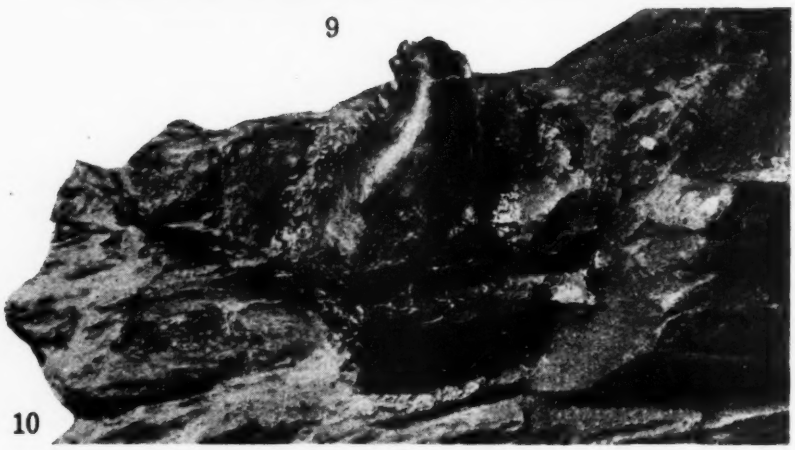

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FIG. *8*—*Troödon* sp. Royal Ont. Museum No. 1445, oblique internal view of anterior portion, showing remnants of teeth; ×6. (p. 627)
9—The same, oblique internal view of middle portion of alveolar margin, showing tooth; ×6.
10—The same, internal view of posterior portion of alveolar margin, showing tooth; ×6.

broadly U-shaped, with the tooth rows directed forward and outward, as well as upward. This in turn suggests a skull of relatively broad proportions, like that in the Iguanidae.

MEASUREMENTS

Maximum length of dentary.....	53.9 mm.
Maximum height of dentary.....	14.6 mm.
Height of largest tooth, as preserved	5.7 mm.

The reasons for referring the above described dentary to *Troödon* Leidy are based on the characters of the preserved teeth, as follows:

(a) absence of fluting on the crowns;
(b) no construction at the roots;
(c) transverse banding of the enamel colour pattern.

These are all characteristic features of the type or of the referred specimens in the National Museum of Canada (Sternberg, 1945). The present specimen, therefore, fully confirms Sternberg's view that *Troödon* Leidy is entirely distinct from *Stegoceras* Lambe, as described by Gilmore (1924) under the name of *Troödon*. *Stegoceras* is a small ornithopod (Russell, 1932, Brown and Schlaikjer, 1943). *Troödon*, as known at present, appears to be a small theropod, for the following reasons:

(a) the posterior teeth are blade-shaped, with anterior and posterior cutting edges, as in deinodonts and other theropods;
(b) the anterior teeth are nearly cylindrical, as in deinodonts;
(c) the transverse colour banding of the enamel is similar to that of theropods and crocodiles;
(d) the area of wear is an oblique facet, as in deinodonts, not a truncation, as in ornithopods;
(e) the pitting of the dentary externally, and the presence of a long Meckelian groove internally, resemble the conditions in theropods;
(f) the evident absence of a predentary precludes reference to the Ornithopoda.

Among known theropods the teeth most closely resemble those of *Velociraptor* Osborn (1924) from the Upper Cretaceous of Mongolia, and *Dromaeosaurus* Matthew and Brown (1922) from the Oldman formation of Alberta. In these genera, however, the mandible and skull are narrow and elongate.

On the basis of the available material the systematic position of *Troödon* may be redefined as follows.

Order SAURISCHIA
Suborder THEROPODA
Family TROÖDONTIDAE, redefined

Small carnivorous reptiles with delicate teeth, those in anterior positions cylindrical, the remainder compressed blade-shaped, distinctly recurved, with anterior and posterior edges denticulate rather than serrate; symphysial junction flat but not intimately united; mandible broadly U-shaped; skull probably relatively broad.

Genus TROÖDON Leidy

This being at present the only known genus, the generic characters are indistinguishable from those of the family.

TROÖDON FORMOSUS Leidy

Leidy's type has well developed denticulations on the anterior edge, as do some of the teeth from Alberta. The teeth of the above-described dentary have the anterior denticulations much weaker, and are considerably smaller in size. For the present, however, it is best to recognize only one species.

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JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 5, PP. 630–631, 1 TEXT FIG., SEPTEMBER 1948

CHIMAEROID FOSSIL EGG CAPSULES FROM ALBERTA

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ABSTRACT—A new species of chimaeroid egg capsule, *Chimaerotheca stelcki*, is described, and its stratigraphic horizon is discussed.

INTRODUCTION

ROLAND W. BROWN'S recent paper (1945) in the JOURNAL OF PALEONTOLOGY on specimens he identifies as fossil egg capsules of chimaeroid fishes was very opportune, as similar specimens had just been added to the collections of the Department of Geology, University of Alberta, and had not been identified. The specimens were collected by C. R. Stelck of the Imperial Oil Limited, in the foothills of the Peace River area from the Nikinassin formation, and believed to be Upper Jurassic in age. Stelck reports that these egg capsules are sufficiently common at this horizon to use as index fossils, but only two specimens were collected.

FIG. 1—*Chimaerotheca stelcki* Warren, n. sp. The holotype, ×0.6.

CHIMAEROTHECA STELCKI Warren, n. sp.
Text figure 1.

The species shows a marked similarity to *C. newmexicana* Brown, differing in being about half the size of that species, with slight differences in the shape of the embryo case and character of the rugae of the membrane. The total length of the capsule of the holotype (Jr. 525) as preserved is 12 cm. and the original length was probably less than 14 cm. The total width as preserved is 6 cm. and the greatest width of the membrane on either side is 2.5 cm. The paratype (Jr. 526) appears to be of a similar size, but the extremities are not sufficiently complete for accurate measurement. The trunk of the embryo case of the new species is regularly spindle-shaped, the greatest width being at the middle and not below the middle as in *C. newmexicana*. The rugae of the membrane attached to the lower part of the trunk usually divide into three branches, but on the upper part of the trunk and on the snout portion divide into two branches or are single, the point of division here being quite close to the proximal end instead of a distance of about a centimeter as they are lower down. The rugae on the snout portion of the membrane are more nearly horizontal than on the trunk portion. The rugae on the tail portion of the membrane are difficult to determine but appear to be sharply defined and not subject to division.

AGE AND STRATIGRAPHICAL RELATIONSHIPS

The holotype (Jr. 525) was collected from the Nikinassin formation (1023 feet above the base), on Sulphur River, tributary to the Smoky River which flows into Peace River. Associated with the form were the pelecypods, *Aucella* and *Mclearnia*? and some scaphopods. The paratype (Jr. 526) was collected from a horizon about 50 feet lower on Sheep River, another tributary of the Smoky, and was associated with *Pentacrinus* columnals and a species of *Pleuromya*. The fauna is not well preserved. The species of *Aucella* present are Jurassic rather than Cretaceous types. *Mclearnia* was described by C. H. Crickmay (1930) from the Harrison Lake area, British Columbia, and was considered Lower Cretaceous in age. The genus *Pentacrinus* has a long time range, but in western North America is most abundant in the Upper Jurassic. Both stratigraphic and paleontologic evidence would tend to place this fauna in the Upper Jurassic rather than in the Lower Cretaceous.

MANUSCRIPT RECEIVED JAN. 24, 1948

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JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 5, PP. 632–633, PL. 93, SEPTEMBER 1948

A NEW CRETACEOUS CALCAREOUS ALGA FROM KANSAS

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Colorado School of Mines and Princeton University

THROUGH the kindness of Mr. E. R. Eller, Curator of Geology and Invertebrate Paleontology in the Carnegie Museum, the writers are permitted to describe a new and remarkable form of calcareous alga recently found in the Upper Cretaceous Niobrara formation of Kansas. This alga appears to represent a new genus, as well as a new species.

Class CHLOROPHYTA
Family CODIACEAE
PLATYLITHOPHYCUS Johnson and Howell, n. gen.

Genotype: *Platylithophycus cretaceum*, new sp.

Plant consisting of a number of long flat fronds, the outer surfaces of which appear to have been covered with tiny hexagonal plates of calcium carbonate, from some of which grow many-segmented filaments that are coated with lime and sometimes divide into branches.

PLATYLITHOPHYCUS CRETACEUM Johnson and Howell, n. sp.
Plate 93, figures 1 and 2

Plant consisting of many flat fronds about six inches long and half an inch wide. The fronds expanded a little as they grew, so that they were wider at their outer ends than they were near their points of attachment.

Each frond appears to have been covered with a layer of tiny hexagonal plates of calcium carbonate which probably formed a tessellated coat over its entire surface. These plates are made up of tiny crystals that radiate from the center of the plate.

From this tessellated coat (or from the outer layers of cells of the fronds if the tessellated coat was not wholly external) there grew many thread-like filaments that sometimes bifurcated and were also covered with calcium carbonate that was arranged in short segments. These filaments were about 1/32 of an inch thick and two inches or more long, and each segment was 1/32 of an inch long. The fossilized filaments resemble in appearance those of the lower part of a plant of the calcareous alga, *Penicillus nodulus* Blainville (one of the Codiaceae) or those of *Amphiroa* (one of the Corallinaceae), but sometimes two filaments of our alga appear to have coalesced and continued to grow as one.

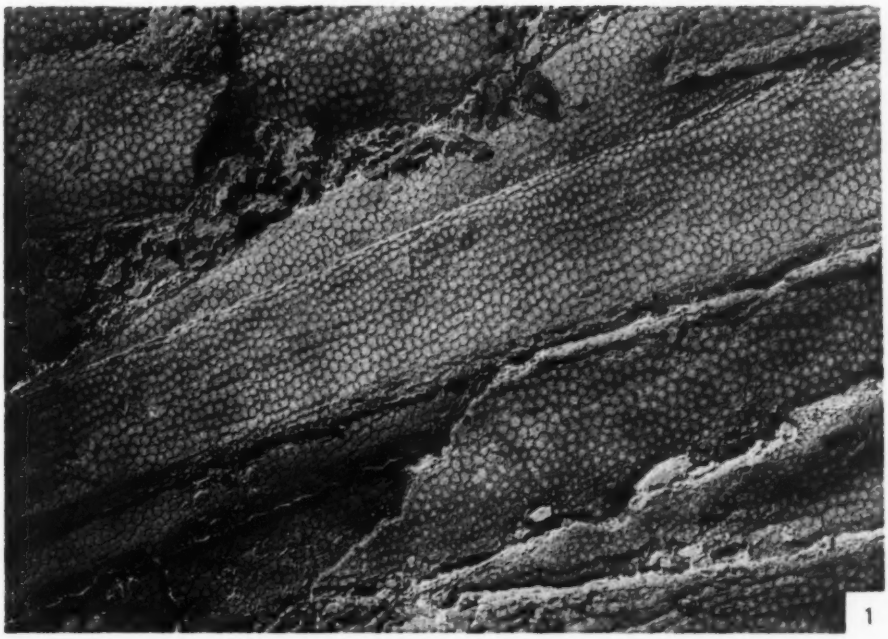
It has not been possible to determine from our specimen just how these filaments were related to the hexagonal plates that coated the main fronds of the plant. Perhaps the tessellated layer was not a wholly external covering, but was encased in living cells, from some of which the filaments grew. The filaments appear to have grown from both sides of the fronds and they were so numerous that, where the fronds lie flat on the bedding surface, as they do in our specimen, the filaments form an almost matted layer above and beneath them.

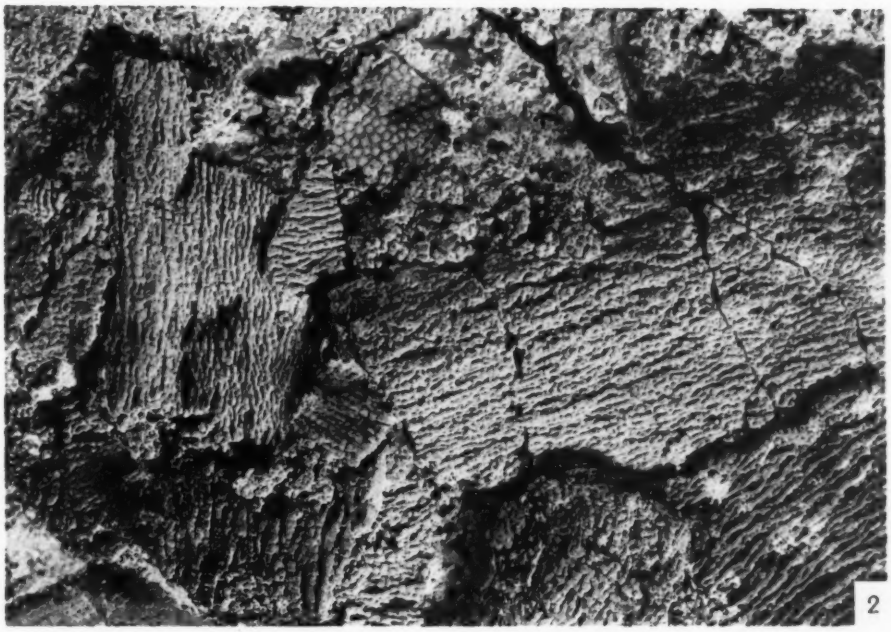
Location of Types.—The holotype and only known specimen is No. 25758 in the paleontological collection of the Carnegie Museum, of Pittsburgh. Fragments of the holotype are No. JA 5018 in the Johnson collection of the Colorado School of Mines and No. 59554 in the collection of Princeton University.

Horizon and locality.—Upper Cretaceous, Niobrara formation, 3 miles northeast of Monument Rocks, Cove County, Kansas.

EXPLANATION OF PLATE 93

FIG. 1—*Platylithophycus cretaceum* Johnson and Howell, n. sp., ×2.5. Top view of fragments showing the small calcareous plates. (p. 632)
2—Bottom view of same, ×2.5.





Johnson and Howell, Kansas Cretaceous Alga

Remarks.—Little can be discerned from the specimen in the way of microstructure. Hence it cannot be definitely classified. The classification suggested is based on superficial appearance.

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JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 5, PP. 634–640, SEPTEMBER 1948

EOCENE FRESH-WATER MOLLUSCA FROM WYOMING

TENG-CHIEN YEN

ABSTRACT—This paper records 15 species of fresh-water mollusks from Eocene localities in central and southwestern Wyoming and interprets them on the basis of the previously recorded faunas to be assignable in part to the lower Eocene and in part to the middle Eocene.

THE present paper deals with nine lots of fresh-water mollusks from Eocene beds in central and southwestern Wyoming, collected by members of the U. S. Geological Survey and of the Smithsonian Institution. Through the kindness of these institutions the material is entrusted to me for study.

The collections contain five species of Wasatchian Mollusca, representing four genera in four families, and 10 species of Bridgerian Mollusca in six genera and five families. Only one species, *Goniobasis tenera* (Hall), is common to the deposits of both ages, though another, *Physa pleromatis* White, originally described from Last Bluff, Utah, in a deposit of Wasatchian age, has a close relative of smaller size in the Bridger beds.

In completing this work, I wish to thank the Geological Society of America for a grant in aid from the Penrose Bequest. The work was carried on in the Department of Geology of the University of Glasgow; to Prof. T. Neville George, I tender my heartfelt thanks for his suggestions and his kindness in providing the research facilities of his department for my convenience.

SUMMARY OF PREVIOUS RECORDS

Eocene Mollusca from the Rocky Mountain area were studied in early years by Meek and White and in recent years by Cockerell, Henderson, Russell and myself. The following is a summary list of the molluscan species that have been described from the Eocene deposits of the Rocky Mountain States:

The Bridgerian stage:

Unio washakiensis Meek—Washakie
Unio grangeri Cockerell—Washakie
Unio haydeni Meek—Bridger
Unio leanus Meek—Bridger
Unio clinopisthus White—Green River
Unio shoshonensis White—Green River
Viviparus wyomingensis Meek—Bridger
Hydrobia gregorii Meek—Bridger
Goniobasis arcta Meek—Bridger
Goniobasis simpsoni Meek—Bridger
Goniobasis tenera (Hall)—Green River and Bridger
Lymnaea minuscula White
Physa bridgerensis Meek—Bridger
Planorbis aequalis White—Green River [=a young form of *Australorbis spectabilis* (Meek)]
Australorbis spectabilis (Meek)—Green River
Australorbis utahensis (Meek)—Green River
Anisus cirrus (White)—Green River

The Wasatchian stage:

Unio mendax White—Wasatch
Unio whitei Henderson—Wasatch [= *Unio rectoides* White]
Unio sinopae Cockerell—Gray Bull
Unio wasatchensis Cockerell—Wasatch
Unio didymictides Cockerell—Gray Bull
Viviparus ionicus White—Wasatch
Viviparus jepsoni Russell—Gray Bull
Viviparus paludinaeformis (Hall)—Wasatch
Hydrobia recta White—Wasatch
Hydrobia utahensis White—Wasatch
Goniobasis filifera White—Wasatch
Goniobasis carterii Conrad—Sand Coulee
Goniobasis nodulifera Meek—Wasatch
Lymnaea minuscula White—Wasatch
Physa bullatula White—Wasatch
Physa pleromatis White—Wasatch
Planorbis storchi Russell—Gray Bull

With the exception of a few records made in recent years, for many of the species described from the Eocene beds definite data on exact stratigraphic position are not provided. This is confusing, particularly in places where the Wasatch and the Green River beds (lower part) interdigitate. Moreover, the differentiation between the Fort Union formation, of Paleocene age, and the Wasatch formation, of lower Eocene age, has been an unsettled question for the last quarter of a century, so that many species characteristic of the Fort Union have been assigned to the Wasatch. Efforts have been made by careful checking and elimination in

TABLE I. EOCENE FRESH-WATER MOLLUSCA FROM WYOMING

	Wasatchian			Bridgerian							
	Previous records	W1	W2	Previous records	B1	B2	B3	B4	B5	B6	B7
Viviparus ionicus	x										
V. paludinaeformis	x	x	x								
V. jepsoni	x										
V. wyomingensis				x		x		x			
Hydrobia recta	x										
H. utahensis	x										
H. gregorii				x							
Goniobasis carterii	x	x									
G. nodulifera	x					x					
G. filifera	x										
G. arcta				x							
G. simpsoni				x							
G. tenera		x	x	x		x					x
Ferrissia cf. *F. minuta*		x									
Lymnaea minuscula	?x			?x							
L. similis				x					x	x	x
L. vetusta				x					x		
L. sp. undet.									x	x	
Physa bullata	x										
P. pleromatis	x								*x		
P. bridgerensis				x					*x		
Physa sp. undet.			x							x	
Gyraulus storchi	x										
Australorbis spectabilis				x			x	x	x	x	
A. cf. *A. spectabilis*											x
Anisus cirrus				x							
Vertigo arenula				x					x	x	
V. atavuncula				x							
Unio mendax	x										
U. whitei	x										
U. sinopae	x										
U. wasatchensis	x	x									
U. didymictides	x										
U. washakiensis			x	x							
U. grangeri				x							
U. shoshonensis				x	*x						
U. haydeni											x
U. leanus				x							
U. clinopisthus				x							

* Related form.

the compilation of the above list to provide an adequate basis for comparison with the new material considered in the present paper (Table I).

LOCATION OF THE COLLECTIONS AND THEIR CONTENTS

Nine collections of fresh-water Mollusca from central and southwestern Wyoming are treated in the present paper. The material from the type area of the Bridger formation in the Bridger basin was found in association with vertebrate remains. Although few elements are now available, they are very helpful, but further intensive collecting is necessary before we can have a precise conception of the molluscan fauna existing in the middle Eocene over the Rocky Mountain States.

Locality W1.—From Sec. 36, T. 14 N., R. 102 W., about 2 miles north of Rife's Ranch on highway toward Rock Springs, Sweetwater County, Wyoming, on east side of road and near road level. R. W. Brown, U. S. Geological Survey.

Viviparus paludinaeformis (Hall)
Goniobasis carterii Conrad
Goniobasis tenera (Hall)
Ferrissia cf. *F. minuta* (Meek and Hayden)
Unio wasatchensis Cockerell

From the same locality, in a bed about 100 feet above the preceding exposure, were obtained the following forms:

Viviparus sp. undet.
Goniobasis tenera (Hall)

Locality W2.—Center Sec. 29, T. 47 N., R. 97 W., Hot Springs County, Wyoming; an exposure near the base of Tatman beds. D. H. Eargle, U. S. Geological Survey.

Viviparus paludinaeformis (Hall)
Goniobasis tenera (Hall)
Physa sp. undet.
Unio washakiensis Meek
Unio sp. undet.

Locality B1.—In or near Sec. 21, T. 15 N., R. 111 W., about 2 miles west of Smithsonian Institution Camp no. 2, north of Cedar Mountain, Bridger Basin, Sweetwater County, Wyoming; in association with crocodile skeleton, specimen no. 53-41, C. L. Gazin, U. S. National Museum.

Unio cf. *U. shoshonensis* White

Locality B-2.—From Bridger "B" along Black's Fork, near U. S. Highway 30, between Church Buttes and Millerville, Sweetwater County, Wyoming. C. L. Gazin, U. S. National Museum.

Viviparus wyomingensis (Meek)
Goniobasis nodulifera (Meek)
Goniobasis tenera (Hall)

Locality B3.—In or near Sec. 1, T. 13 N., R. 110 W., near prominent white layer of Twin Buttes, Sweetwater County, Wyoming; in association with vertebrate specimen no. 22–41. C. L. Gazin, U. S. National Museum.

Australorbis spectabilis (Meek)

Locality B4.—Above or in Lone Tree white layer of the Bridger beds, on south side of Cedar Mountain along Henry's Fork, Sweetwater County, Wyoming; in association with vertebrate specimen no. 74–41. C. L. Gazin, U. S. National Museum.

Viviparus wyomingensis (Meek)
Australorbis spectabilis (Meek)

Locality B5.—Approximately Sec. 9, T. 39 N., R. 88 W., Natrona County, Wyoming. H. A. Tourtelot, U. S. Geological Survey.

Lymnaea similis Meek
Lymnaea vetusta Meek
Lymnaea sp. *undet.*
Physa cf. *P. bridgerensis* Meek
Physa cf. *P. pleromatis* White
Australorbis spectabilis (Meek)
Vertigo arenula (White)

Locality B6.—Approximately Sec. 9, T. 39 N., R. 92 W., East Fork of Dry Creek, about 12 miles northwest of Lysite Mountain, Fremont County, Wyoming. H. A. Tourtelot, U. S. Geological Survey.

Lymnaea similis Meek
Lymnaea sp. undet.
Physa sp. undet.
Australorbis spectabilis (Meek)
Vertigo arenula (White)

Locality B7.—Approximately Sec. 32, T. 39 N., R. 88 W., Natrona County, Wyoming. H. A. Tourtelot, U. S. Geological Survey.

Goniobasis tenera (Hall)
Lymnaea similis Meek
Australorbis cf. *A. spectabilis* (Meek)
Unio haydeni Meek
Unio sp. undet.

AGE OF THE DEPOSITS

The deposits at localities W1 and W2 are probably of Wasatchian age, lower Eocene; those of localities B1, B2, B3 and B4 are of Bridgerian age, middle Eocene. The beds exposed at B5, B6 and B7 are possibly equivalent to the Bridger proper, so far as is indicated by the available fossil material, and may belong to the uppermost part.

The Wasatchian stage may be considered to be characterized by *Viviparus paludinaeaformis* (Hall) and *Goniobasis carterii* Conrad. These species are common in distribution and abundant in individuals and suggest that the enclosing rocks are of fluviatile origin. The presence of a form closely related to *Ferrissia minuta* (Meek and Hayden), a species of the Fort Union formation, of Paleocene age, in the deposit at W1 may imply that this bed is an early part of the Wasatch, in which this form had survived. On the other hand, the deposit at W2 may occupy a higher stratigraphic position within the Wasatch formation.

The collections from localities B1, B2,

B3 and B4 were made in the type area of the Bridger formation, in association with vertebrate remains. It seems to be clear that, with the exception of *Goniobasis tenera* (Hall), the molluscan species of these deposits are different from those of the Wasatchian.

As to the age of the deposits from localities B5, B6, and B7, the conclusion reached is less definite. On the basis of a collection made at the northeastern end of the Lysite Mountains, Wyoming, I suggested in a previous paper (Yen 1946) that the mollusk-bearing bed at that locality is equivalent to the Bridger formation. This suggestion may also apply to the beds now under consideration, for the presence of such characteristic species of the Bridger as *Australorbis spectabilis* (Meek), *Lymnaea similis* Meek, and *Vertigo arenula* White in the same bed seems to furnish strong evidence. However, modification of the elements in the assemblage is present. In the collection from the three localities, 6 out of 12 previously known species of the Bridgerian gastropods are recorded, about 50 percent. At the same time, new elements seem to be appearing, including varieties of *Physa pleromatis* and *P. bridgerensis*, and a variety of *Australorbis spectabilis*. These forms in the present collections are not reported in previous records of the Bridger formation, and their significance is not now clear, but they do suggest that these beds may be assigned to an upper part of Bridgerian.

The possibility of assigning these beds to a later stage, the Uintan or Duchesnean of the upper Eocene, should also be taken into consideration. However, this possibility does not seem very probable. First, the polygyral species *Australorbis spectabilis* is quite characteristic and recalls strongly its European contemporary, *"Planorbina" pseudoammonius*, which has been never recorded anywhere above the Lutetian stage; second, a combination of species of the Bridger formation surviving to a later age would present a problem difficult to elucidate in the history of evolution.

A comparison of the characteristic mol-

TABLE II. COMPARISON OF THE CHARACTERISTIC SPECIES OF MOLLUSCA IN EOCENE BEDS

Epochs		North American provincial ages	Vertebrate Faunal zone	Characteristic molluscan species	Possible equivalent European stages and characteristic species of Mollusca
Eocene	Upper	Duchesnean and Uintan	*Teleodus* and *Amynodon*	?	Ludian *Viviparus lentus* *Hydrobia pusilla* *Lymnaea longiscata* *Planorbis similis* *Planorbis casterensis* *Planorbis euomphalus* Bartonian
	Middle	Bridgerian (including Washakie and the Green River formations)	*Orohippus*	*Viviparus wyomingensis* *Goniobasis simpsoni* *Australorbis spectabilis* *Anisus cirrus* *Vertigo arenula* *Unio haydeni*	Lutetian *Viviparus viviparoides* *Valvata bouryi* *Lymnaea michelini* *"Planorbis" pseudoammonius* *"Planorbis" chertieri*
	Lower	Wasatchian (including the Lost Cabin, the Lysite, the Gray Bull and the Sand Coulee formations	*Hyracotherium*	*Viviparus paludinaeformis* *Goniobasis carterii* *Goniobasis filifera* *Unio wasatchensis*	Ypresian *Viviparus suessonensis* *Menetus cuisensis* *Unio truncatosus* Sparnacian

luscan species of the Wasatchian and Bridgerian with their generally accepted equivalents in Europe is shown in Table II.

SYSTEMATIC NOTES

UNIONIDAE

UNIO WASATCHENSIS Cockerell

Unio wasatchensis, COCKERELL, 1914, Amer. Mus. Nat. Hist. Bull., 33, p. 105. (Type locality: Wasatch Tertiary, Big Horn Basin, Wyoming.)

Two valves and a few fragments were collected from locality W1. The left valve has its anterior half preserved, and the right valve is somewhat distorted; however, judged by tracing its growth lines, the general outline of the right valve together with the preserved hinge feature on the left valve seems to justify assignment to this species.

UNIO WASHAKIENSIS Meek

Unio washakiensis, MEEK, 1871, U. S. Geol. and Geogr. Survey Territories, 4th Ann. Rept., p. 298, WHITE, 1883, U. S. Geol. and Geogr. Survey Terr., 12th Ann. Rept., pt. 1, p. 42, pl. 19, fig. 3. (Type locality: Washakie, Wyoming.)

This species is recognized by its oblong outline. Four specimens obtained from locality W2 are mostly represented by moulds, only one having its shell partly preserved. Several specimens in the same lot with an ovate outline have not been satisfactorily identified and may possibly represent a distinct species.

UNIO SHOSHONENSIS White

Unio shoshonensis, WHITE, 1876, in Powell's Rept. geol. eastern portion Uinta Mts., p. 104 U. S. Geol. Geogr. Survey Terr., 12th Ann. Rept., pt. 1, p. 41, pl. 19, fig. 2, 1883. (Type locality: Green River Tertiary, west side Snake River, 6 miles north of Junction Mt., Colorado.)

Six specimens from locality B1 seem to belong to this species, which has an ovately oblong outline and strongly sculptured growth lines. The specimens are all closed valves in somewhat distorted condition.

UNIO HAYDENI Meek

Unio haydeni, MEEK, 1860, Acad. Nat. Sci. Phila. Proc., 12, p. 312; U. S. Geol. Explor. 40th Parallel Report, vol. 4, pt. 1, p. 184, pl. 16 fig. 3, 1876. (Type locality: Base of Uinta Mts., near Fort Bridger, Wyoming.)

Three specimens from locality B7 agree in size and general outline with this species. In the same lot a species of large size (about 80 mm. in length and 65 mm. in height) and of thick shell substance occurs; it is, however, imperfectly preserved and it is at present specifically undeterminable.

VIVIPARIDAE

VIVIPARUS PALUDINAEFORMIS (Hall)

Turbo paludinaeformis, HALL, 1845, Frémonts Exped. Rocky Mts., Oregon and North California, p. 309, pl. 3, fig. 13;
Viviparus paludinaeformis, WHITE, 1883, U. S. Geol. Survey 3rd Ann. Rept. p. 468, pl. 30, fig 11–12. (Type locality: Lat. 41° 30′ N., Long. 111° W. About 20 miles N. of Evanston, Wyoming.)

This species is characterized by its ovate and slightly elongated outline. Several specimens were collected from locality W1, in association with *Goniobasis tenera* in a matrix of hard shale. Another lot of numerous examples was found at locality W2, also in association with *G. tenera*, but they were imbedded in sandy shale.

VIVIPARUS WYOMINGENSIS Meek

Viviparus wyomingensis, MEEK, 1871, Acad. Nat. Sci. Phila. Proc., vol. 23, p. 182; WHITE, U. S. Geol. Survey 3rd Ann. Rept., p. 468, pl. 30, fig. 13–14, 1883. (Type localities: Henry's Fork, Black's Fork, Church Buttes, Wyoming.)

This species differs from the preceding one by its more globose outline and conically shaped spire. Several specimens were found at localities B2 and B4, in association with either *Goniobasis nodulifera* or *Australorbis spectabilis*.

PLEUROCERIDAE

GONIOBASIS CARTERII Conrad

Goniobasis carterii, CONRAD, 1868, Amer. Jour. Conch., 4, p. 280, pl. 18, fig. 6, 7. (Type locality: Tertiary, Barrel Springs, Wyoming.)

This species seems to be characterized by its strongly nodulated sculpture together with its stout shell outline. The specimens were obtained from locality W1, a few of them quite well preserved.

GONIOBASIS NODULIFERA Meek

Goniobasis nodulifera, MEEK, 1871, U. S. Geol. and Geogr. Survey Terr., 4th Ann. Rept., p. 299. (Type locality: Lat. 41° 31′ N., Long. 111° W. = *Cerithium nodulosum* Hall. About 20 miles north of Evanston, Wyoming.)

One specimen that bears a single row of strong nodulations on the whorl surface seems to represent this species. The species

is generally considered a Wasatch form, but its type locality is uncertain and it may be a Bridger species.

GONIOBASIS TENERA (Hall)

Cerithium tenerum, HALL, 1845, Frémont's Exped. Rocky Mts. Oregon and North California, p. 308, pl. 3, fig. 6. (Type locality: S.W. Wyoming.)

This species is recognized by its long, slender outline, and fine sculpture of spiral lines and riblets. It has been found in both Wasatch and Bridger beds. The Bridger specimens seem to be generally of smaller size and broader outline, which may justify their separation as a distinct form.

ANCYLIDAE

FERRISSIA cf. F. MINUTA (Meek and Hayden)

Velletia (*Ancylus*) *minuta*, MEEK and HAYDEN, 1856, Acad. Nat. Sci. Phila., Proc., vol. 8, p. 120.

Acroloxus minutus, MEEK, 1876, U. S. Geol. Geogr. Survey Terr., Monogr. 9, p. 543, pl. 44, fig. 10. (Type locality: 3 miles below Fort Union, N. Dakota.)

Two specimens were found in a dark-brown shale in association with *Goniobasis tenera*. A more mature example is represented by a mould only. The specimens are smaller in size than the typical form of the species, which was described from the Fort Union formation. They probably belong to a distinct species; but distinction can be definitely established only on better preserved specimens.

LYMNAEIDAE

LYMNAEA SIMILIS Meek

Limnaea similis, MEEK, 1860, Acad. Nat. Sci. Phila. Proc., vol. 12, p. 314.; U. S. Explor. Great Basin of Utah Report, p. 367, pl. 5, fig. 2a, b, 1876; Yen, Jour. Paleontology, vol. 20, no. 5, p. 497, fig. 2, 1946. (Type locality: Tertiary, Ham's Fork, N.E. of Bridger, Wyoming.)

Five specimens were obtained from locality B5 and two from B7. One of the well-preserved specimens is 7 mm. high, 4 mm. wide, and has about 5 whorls. Its spire is nearly as high as the body whorl and the whorl surfaces are scarcely convex. The type specimen is about 11 mm. high, 6 mm. wide, and has about 6 whorls; it is probably a more mature shell.

LYMNAEA VETUSTA Meek

Limnaea vetusta, Meek, 1860, Acad. Nat. Sci. Phila. Proc., vol. 12, p. 314; U. S. Explor. Great Basin Utah Report, p. 365, pl. 5, fig. 3a, b, 1876. (Type locality: Tertiary, Ham's Fork, NE. of Fort Bridger, Wyoming.)

More than a dozen examples from locality B5 agree well with this species. It differs from the preceding in its larger size, more slender shell outline, and more narrowly conical spire. However, these differences may be no more than subspecific in *Lymnaea*.

LYMNAEA sp. undet.

This form is characterized by its large size (about 15 mm. high and 6.8 mm. wide), oblong shell outline, highly elevated spire, and scarcely convex whorls. Its general outline resembles that of *Lymnaea stagnalis*, but it is much smaller. Five specimens were found at locality B5, including a few young ones, and three at locality B6.

PHYSIDAE

PHYSA cf. P. PLEROMATIS White

Physa pleromatis, WHITE, 1877, U. S. Geol. and Geogr. Survey W. 100th Mer., vol. 4, pt. 1, p. 211, pl. 21, fig. 1. (Type locality: Last Bluff, Utah.)

This form is represented at locality B5 by numerous specimens. It differs from typical *P. pleromatis* in its much smaller size and in having fewer whorls, and may be viewed as representing the younger stages.

PHYSA cf. P. BRIDGERENSIS Meek

Physa bridgerensis, MEEK, 1873, U. S. Geol. and Geogr. Survey Terr., 6th Ann. Rept., p. 516; WHITE, U. S. Geol. and Geogr. Survey, W. of 100th Mer., vol. 4, pt. 1, p. 210, pl. 21, fig. 2, 1877. (Type locality: Church Buttes, 14 miles from Fort Bridger, Wyoming.)

This is represented at locality B5 by numerous examples. It differs from typical *P. bridgerensis* Meek by its much smaller size and fewer whorls. It may be considered as representing the younger stages. *P. bridgerensis* differs from *P. pleromatis* by its narrower outline and higher spire, which forms a more acute angle.

PHYSA sp. undet.

This form is characterized by its subcylindric outline, acute spire, and narrowly dilated body whorl. It differs from *Physa bridgerensis* by its much smaller size and

more cylindric outline. The largest specimen in the present collection is 10 mm. high, 4.8 mm. wide, and has about 5 whorls. There are five examples from locality B5, and six from B6.

PLANORBIDAE

AUSTRALORBIS SPECTABILIS (Meek)

Planorbis spectabilis, MEEK, 1860, Acad. Nat. Sci. Phila. Proc., vol. 12, p. 314; U. S. Geol. Explor. 40th Parallel Report, vol. 4, pt. 1, p. 189, pl. 17, fig. 13, 1877.

Australorbis spectabilis, Yen, Jour. Paleontology, vol. 20, no. 5, p. 497, fig. 5a, b, 1946. (Type locality: Ham's Fork, S. W. Wyoming.)

Specimens typical of this species are numerous at localities B5 and B6. Five examples from locality B7 may represent a variety differing by its larger size, by having apical and umbilical views almost equally perspective, and by a less rapid increase in the size of the whorls.

PUPILLIDAE

VERTIGO ARENULA (White)

Pupa arenula, WHITE, 1876, in Powell's Report Geol. eastern portion Uinta Mts., p. 105; U. S. Geol. and Geogr. Survey Territories, 12th Ann. Rept., pt. 1, p. 46, pl. 19, fig. 8, 1883.

Vertigo arenula, Yen, Jour. Paleontology, vol. 20, no. 5, p. 498, fig. 10, 1946. (Type locality: Henry's Fork, Wyoming.)

Two examples from locality B5 and one from B6 agree well with this species, which has a broader shell outline than *Vertigo atavuncula*, and bears two strong crests on the outer wall of the peristomal margin. The aperture of the present specimens is not preserved, but they may still be identified by their broad shell outline. *V. arenula* has been found in places in the same bed with *V. atavuncula*.

MANUSCRIPT RECEIVED FEB. 4, 1948.

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JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 5, PP. 641–646, SEPTEMBER 1948

NOMENCLATURAL NOTES

LEGAL STATUS OF OPINIONS RENDERED BY THE I.C.Z.N.

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IN A recent issue of this Journal Knight and Weller (1948, p. 109) think it "logical to conclude that Opinions concerned with interpretations of the Rules are comparable to decisions of a supreme court and thus become part of the law."

As a trained jurist, I was induced by that utterance to examine this problem from a formally legal angle.

First, it might be well to point out that decisions of a supreme court do not necessarily "become part of the law." They certainly do not wherever there exists a codified law. This being the case in the field of zoological nomenclature (Règles Internationales de la Nomenclature Zoologique), the question as to what holds true for legal systems without codified law need not bother us here.

Hence it would follow that Opinions rendered by the I.C.Z.N.—with the exception dealt with in the last paragraph of this article—are, as such, not binding. This conclusion is fully confirmed by the following sentence of the introduction to the publication of Opinions 1–25 (1910, p. 2), whose author is apparently Dr. C. Wardell Stiles, then the Commission's Secretary: "The Commission has no legislative power. Its powers are restricted to studying questions of nomenclature, to reporting upon such questions to the International Congress, and to rendering opinions upon cases submitted to it."

There prevails, however, an important qualification of the result just arrived at. As long as opinions have merely been rendered by the Commission, they are—again with the exception mentioned above—indeed not yet "part of the law." However, the Commission submits, quite regularly and immediately as it seems, the opinions, as part of its report, to the International Zoological Congress.[1] Inasmuch as the Congress—as it is the rule—adopts that report, it thereby ratifies the Commission's opinions. Since the International Zoological Congress acts as the legislating body in matters of zoological nomenclature, it is this ratification by the Congress, *and only this ratification*, which makes opinions of the Commission—other than those suspending the rules—binding and indeed, as Knight and Weller assume, "part of the law." Should the Congress once reject an opinion submitted by the Commission, that opinion would have no legal standing whatever.

Adoption by the Congress is, however, not required for the validity of opinions of the Commission suspending the Rules, since the Commission acts in such cases for the International Zoological Congress on the strength of the Plenary Power conferred to it by the Congress of Monaco, 1913.

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[1] This procedure was followed in the case of Opinion 138, which is the subject of Knight and Weller's (1948) note, also. (See 1942, p. 32.)

CYPRAEA CORSICANANA, NEW NAME FOR *CYPRAEA GRACILIS* STEPHENSON, PREOCCUPIED

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ON PAGE 314, plate 59, figures 12, 13, of my paper entitled "The larger invertebrate fossils of the Navarro group of Texas," published in 1941 as University of Texas Publication No. 4101, I described a new gastropod from the Nacatoch sand (Maestrichtian) near Corsicana, Texas. Mrs. Katherine V. W. Palmer has kindly called my attention to the preoccupation of this name by *Cypraea gracilis* Gaskoin in the Proceedings of the Zoological Society of London (pt. 16, p. 93, 1849). I therefore propose the name *Cypraea corsicanana* to replace the preoccupied name.

MADRASITES A SYNONYM OF *KOSSMATICERAS S. STR.*

OTTO HAAS
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IN 1901 A. de Grossouvre (pp. 718/9) proposed the generic name *Kossmaticeras* for certain species from the Upper Cretaceous (mostly from the Trichinopoly group) of Southern India which Kossmat (1897, p. 33) had united in the group of "*Holcodiscus*" *theobaldianus* (Stoliczka). This very wording of de Grossouvre's makes it perfectly clear that *Ammonites theobaldianus* Stoliczka is the type species of *Kossmaticeras sensu lato.*

However, Kilian and Reboul (1909, pp. 25–26), when splitting up de Grossouvre's genus into six subgenera, created, as the first of them, *Madrasites* for forms like *K. karapadensis* (Kossm.), *K. bhavani* (Stol.), *K. theobaldianum* (Stol.), thus including in this subgenus the type species of the whole genus *Kossmaticeras*, without leaving any species in *Kossmaticeras sensu stricto.*

Hence the subgeneric name *Madrasites* has to be dropped as a synonym of *Kossmaticeras s. str.*

I am not absolutely certain that this nomenclatural error of Kilian and Reboul's has not been noted before, but I have not been able to find any statement to this effect in the literature. Roman (1938, pp. 410, 411) was certainly not aware of it, for he lists *Ammonites theobaldianus* Stoliczka, quite uncritically, as the type species of both *Kossmaticeras sensu lato* and its subgenus *Madrasites.*[1] This nomenclatural impossibility in a comparatively recent text book enjoying considerable authority seems to justify the present note.

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[1] To make things even worse, Roman (1938, p. 412) lists *K. theobaldianum* also among the species of a third subgenus, *Gunnarites* Kilian and Reboul, to which it certainly does not belong.

THEODENISIA, NEW NAME, REPLACING *DENISIA* CLARK

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MR. ALAN B. SHAW of Harvard University has kindly informed me of the preoccupation of *Denisia*, a name proposed by me for a genus of trilobites (Bull. Amer. Paleontology, vol. 10, no. 41, p. 23, 1924). This name has been used previously by Jacob Hubner for a genus of Lepidoptera (Verz. Bek. Schmett., vol. 27, p. 420, 1825). As a replacement I propose *Theodenisia:* genotype *Theodenisia eminens* (Clark).

REPORT OF POLICY BOARD OF JOINT COMMITTEE ON ZOOLOGICAL NOMENCLATURE OR PALEONTOLOGY IN AMERICA FOR 1947

ORGANIZATION MATTERS

PROF. ALFRED S. ROMER's term as representative of the Society of Vertebrate Paleontology on the Policy Board expired on December 31, 1946. However, he was reappointed by action of his Society at the Chicago meetings in December for the term expiring December 31, 1949, so that the make-up of the Policy Board was the same as the previous year. The same Chairman was re-elected. The term of the representative of the Society of Economic Paleontologists and Mineralogists, who is also Chairman, will expire on December 31, 1947, and that Society has asked Professor Raymond C. Moore to succeed him as its representative until the end of 1950. The choice of the Chairman for 1948 is a function of the Policy Board.

The terms of Dr. Myra Keen, Mrs. Helen J. Plummer, and Prof. Gayle Scott expired at the end of 1946, and Prof. Don L. Frizzell, Mrs. Katherine V. W. Palmer, and Dr. Keen, who succeeded herself, were appointed by the Policy Board for the term ending December 31, 1949. The terms of Prof. Raymond C. Moore, Prof. John W. Wells, and Dr. Henryk B. Stenzel as committee members will expire at the end of 1947. Although Moore comes back to the Committee as the representative of the S. E. P. and M. on the Policy Board, it will be the privilege of the Board to select three members to make up the new class of 1950.

Educational.—In support of its announced primary objective, to encourage "the fullest understanding and use of the official publications of the International Commission on Zoological Nomenclature," the Committee sponsored the following items published in volume 21 of the Journal of Paleontology:

(a) A note entitled *Incorporation of the International Commission on Zoological Nomenclature*, Jour. Paleont., *21*, p. 296.

(b) *Recent publications of the International Commission on Zoological Nomenclature.* Jour. Paleont., *21*, p. 296.

(c) *New names for Junior Homonyms.* Jour. Paleont., *21*, p. 400.

(d) *UNESCO aid for the International Commission on Zoological Nomenclature.* Jour. Paleont., *21*, p. 400.

Secretary Hemming's visit.—Although not officially an act of the Joint Committee, its Chairman, as a member of an interested group at the National Museum, took part in arranging that Mr. Francis Hemming, Secretary of the International Commission, be brought to the United States at the invitation of the Smithsonian Institution. It is planned for Mr. Hemming to address a joint session on nomenclature of two of the Committee's sponsoring societies, the Paleontological Society and the Society of Vertebrate Paleontologists, at their annual meetings at Ottawa on December 31.

The purpose of bringing Mr. Hemming to America is to foster better understanding and co-operation between the International Commission and American zoologists and paleontologists. Such a purpose is, of course, of deep interest to the Joint Committee. Secretary Hemming's visit should be a definite contribution to the educational objective of the Joint Committee.

Nomenclatural Session.—International Paleontological Union. On September 30, 1947, Prof. Benjamin F. Howell, Secretary of the International Paleontological Union, advised your chairman that there would be a session on Nomenclature of Fossils during the meetings of the Union to be held in London in conjunction with those of the International Geological Congress late in August 1948. The Policy Board of the Joint Committee expressed to Secretary Howell and the other officers of the Union its gratification that such meetings were to be held and that the program of the meetings is to include papers and free discussions on nomenclatural matters. However, it expressed the view that the session should not be empowered to pass resolutions on technical matters pertaining to zoological or paleobotanical nomenclature nor on any proposals on the nomenclature of types, for any such definite actions are bound to be interpreted by outsiders (such as the International Commission) as representing the views of World Paleontology, which they may appear to do but in fact cannot do. Furthermore, it expressed the view that the short session of a meeting of numerous people, speaking different languages, is no place to arrive at a well-thought-out conclusion on such a complex subject with such widespread ramifications as Zoological Nomenclature. Secretary Howell advised the Joint Committee Policy Board that so far as he then knew it is not planned to have resolutions or recommendations brought up for action at the Nomenclatural Session.

Aid to American paleontologists.—The second of the announced purposes of the Joint Committee was to give informal aid and advice on nomenclatural matters to American paleontologists. As in the previous year the greater part of such informal assistance was in oral discussions. However, paleontologists have written in more frequently than in past years. Most of such inquiries have been answered by the chairman, but a number of issues were raised that may require more formal action, or perhaps rulings by the International Commission, before they are settled.

One case requesting suspension of the Rules has been transmitted to the International Commssion on behalf of a group of American paleontologists with the Joint Committee's endorsement.

Co-operation with the International Commission.—As announced in the Annual Report for 1946, the experiment was tried of referring questions to sub-committees of three for study and recommendation. The experiment was fairly successful, but actually it neither relieved the burden on the Chairman materially, nor did it seem to accomplish results as satisfactorily as had been hoped. The difficulty seems to be the same handicap under which the Committee as a whole suffers, the inability of the members of even small sub-committees to meet for face-to-face, give-and-take discussion. Since all discussion must be carried out by correspondence, the results appear not to be so well worked out as if there had been facilities for conferences where differences could have been resolved more reliably and with much less effort. It is suggested that one-man committees to formulate carefully proposals for the consideration of the whole Committee may be the solution. As matters stand, any proposal of a three-man subcommittee must be considered by the whole Committee of 12 members and thrashed out by correspondence, and there is no apparent advantage in the preliminary argumentation by correspondence. One-man sub-committees give promise of being successful in direct ratio to the care taken by the selected man to work up a proposal thoroughly. Diffusion of responsibility may be the weak point of the three-man sub-committees, if there is one, and the one-man sub-committee may be the solution.

Of the four sub-committees appointed in 1946 to consider and recommend on specific problems, two have submitted final reports —those of Newell on subspecific names, and Keen on genera founded on figures only. The Stenzel sub-committee on "neotypes" has made a preliminary report. The Wells' sub-committee on naming tracks, trails, borings, etc., is said to have done some work but has made no report. One or two other minor matters are open.

What is no doubt the most important group of Committee activities of the year stemmed from what is reported as a lively discussion on Zoological Nomenclature at the S. E. P. and M. annual meetings at

Los Angeles in March. As a result of this discussion Prof. Gayle Scott was delegated to protest through the Joint Committee an Opinion of the International Commission validating *Nummulites* vs. *Camerina*. The Chairman replied that the time to protest is before the Commission has acted, not afterward, that there were a number of petitions involving fossils currently before the Commission for action, and that it would be helpful if Professor Scott would study those petitions and propose specific action on the part of the Joint Committee on each. Professor Scott accepted the challenge, and as a result the Joint Committee passed on to the International Commission in November its recommendations on eight petitions on names of fossils that are before the International Commission.

In addition to the above-mentioned eight recommendations, the Joint Committee submitted to the Commission two further formal recommendations resulting from its consideration of the Newell sub-committee's report on sub-specific names and of the Keen sub-committee's report on genera founded on figures. It likewise sent in with its endorsement a petition of Duncan, Loeblich, and Moore, on the proposed suspension of the Regles in favor of *Fistulipora* McCoy.

Likewise, the Committee passed on to the Secretary of the Commission the views of its members, informally expressed, on two other problems. It also secured and passed on to the Commission the views of Doctors Ruedemann and Decker on certain proposals involving the names of graptolites.

General.—The Chairman feels that this year has demonstrated that the Joint Committee has useful functions and can perform them successfully. To do so involves considerable work on the part of the committee members and particularly of the Chairman, and the necessary method of operation by correspondence is cumbersome. Both these factors are drawbacks. But, as to the first, what worthwhile objective can be accomplished without work? As to the second, no other method of operation seems feasible.

The Chairman wishes to thank his fellow committeemen for their splendid cooperation during his term of office.

Respectfully submitted,

J. BROOKES KNIGHT,
Chairman, Joint Committee on Zoological Nomenclature for Paleontology in America

OSTRACODE GENOTYPES DESIGNATED BY S. A. MILLER

A. SCOTT WARTHIN
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Ostracode genotype designations that have been largely ignored are those published in S. A. Miller's *North American Geology and Paleontology*. This work was issued in 1889 and was supplemented by an appendix in 1892 and a second appendix in 1897. For each genus listed, Miller gives the original reference, the derivation of the name, a diagnosis, and a statement of the type (for *Primitia*, "Type *P. strangulata*"). Miller followed approximately the principles used today for subsequent designation of genotypes, and there can be no doubt of his intent. His choices of type species which differ from the genotypes given in the index published by Bassler and Kellett (1934, pp. 1–500; see U. S. Geol. Survey bibliographies for full citation of references given in this note) are discussed below.

Genus PRIMITIA Jones and Holl 1865

This genus is usually cited as having for its type species *Beyrichia mundula* Jones 1855, but Miller (1889, p. 561) designated *P. strangulata* (Salter) 1852 as type. This species appears in the original list of species assignable to *Primitia*, published by Jones and Holl in 1865, and Miller's designation antedates any other known to the writer. *P. strangulata* must therefore be considered the genotype of *Primitia*. Since *strangulata* is a eurychilinid, the genus *Eurychilina* (Ulrich, 1889, p. 52) will become a synonym of *Primitia*. Furthermore, the species *mun-*

dula Jones, hitherto considered the genotype of *Primitia*, can hardly continue in assignment to that genus. Since the type specimen of *mundula* (Swartz, 1936, p. 565) is a damaged individual collected from glacial drift it seems to the writer unwise that a genus be erected to care for a specimen of such doubtful significance. It is suggested that for the time being it be referred to the allied genus Milleratia Swartz 1936, and be cited as *Milleratia ? mundula* (Jones).

Genus BOLLIA Jones and Holl 1886

The Bassler-Kellett index cites *B. bicollina* Jones and Holl as the type species, but this is antedated by the designation of *B. uniflexa* Jones and Holl by Miller (1892, p. 706). Since these species are closely allied, the shift in genotype does not materially alter the concept of the genus *Bollia*.

Genus HALLIELLA Ulrich 1891

The Bassler-Kellett index cites *Primitia ? sculptilis* (p. 322) and *H. retifera* (p. 17) as the genotype. In a later sheet of errata the reference to *retifera* was removed. Miller, however, (1892, p. 707) designated *retifera* as genotype, and Bassler (1941, p. 22) refers to it as genotype. It is probable that the working concept of this genus is actually based more on this well-known species than on the comparatively rare *sculptilis*.

Genus MOOREA Jones and Kirby 1867

Miller (1892, p. 709) cites *M. silurica* Jones and Holl as genotype, but since *silurica* was not described until 1869, and is not in the original list of species ascribed to this genus, this designation is invalid, and that of *M. obesa*, used in the Bassler-Kellett index, (1934, p. 413) is correct.

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REVIEW

ANELIDEOS POLIQUETOS DOS FOLHELHOS DEVONIANOS DO PARANÁ. (Polychete annelids from the Devonian shales of Paraná, Brazil.) By Frederico Waldemar Lange. Museu Paranense, Arquivos, vol. 6, art. 5, pp. 161–230, 3 text figs., 15 half-tone plates. Curitiba, Paraná, Brazil. 1947 (1948).

This is probably the most important paper yet written on the scolecodonts, and certainly is the most valuable in recent years. It is at the same time a significant addition to knowledge of the South American Devonian fauna, which had previously yielded none of these.

The author reports on a collection numbering thousands of scolecodont specimens, painstakingly amassed over many years from the Ponta Grossa shale of Paraná. Among these are *ten* complete mouthpart assemblages, and several incomplete ones. In this connection, we must recall that previously only five buccal assemblages were known (Mesozoic-Paleozoic), and that not one of these was complete. The reviewer can attest from personal experience as to the rarity of scolecodonts at all horizons in the Ponta Grossa shale, and would in all sincerity label Sr. Lange's collecting labors, alone, as Herculean.

After painstaking analyses and detailed comparisons, both with the Recent marine worms of the Brazilian littoral, and the world literature, zoologic and paleontologic, the author concludes that his really vast material represents a single new species, referable to a new genus and family of the superfamily Eunicea of modern marine worms: Paulinitidae, *Paulinites paranaensis* Lange. This is certainly refreshing restraint!

The sets of complete mouthparts contain elements, which, if known only in dissociation, would be comparable to, if not referable to, a variety of the current "form" genera and species. The author makes all of the comparisons most meticulously, and the results indicate quite clearly the extensive modifications now in order in a considerable mass of the previous literature on the scolecodonts, and probably, by inference, on the conodonts. As for the hundreds of discrete parts, if they were not so numerous, so intergrading, and associated with the complete assemblages, or if treated less expertly, perhaps, they would easily have yielded dozens of new "form" names, both generic and specific. The great mass of material is carefully evaluated, morphologically and statistically, and the chief variations of all parts well illustrated.

This Brazilian study effectively, albeit tacitly, points up the important distinction between zoological reality and paleontologic fantasy in the enumeration of genera and species. Nowhere is the Recent-fossil hiatus more painfully clear than in the widespread paleontological use of "form" categories, so proposed that they must eventually accumulate wholesale in synonymies, in accord with the rules of zoological nomenclature. It is not at all strange that neontologists from time to time accuse us of taking undue advantage of the fragmentary and incomplete nature of our materials. It would be hard to discover a group in the systematic treatment of which our sins in this respect are more manifest than the scolecodonts-conodonts. The usual argument of "geologic convenience" hardly makes our procedure more sound or scientific.

It is possible that the same earnest and prolonged search of many of the conodont-scolecodont horizons that Sr. Lange has made of the Paraná Devonian would yield profitable results in mouthpart assemblages. This is of paramount importance, since only complete mouthpart sets have so far provided a reasonably sound basis for legal taxonomic study. There is a possibility that the usual methods of collecting and preparation are also unsatisfactory for these fossils. The all-too-geologic sample bag collecting habit of the micropaleontologist can hardly be expected to yield such materials. Nor can the usual microtechnique of the laboratory—washing, sieving and/or floatation—rich though the yields of such methods are in dissociated hardparts (and in resultant abundance of "form" genera and species). Far be it from the reviewer to belittle the collecting methods or laboratory techniques of the micropaleontologist,—but, for such

fossils as these complex, easily dissociated worm mouthparts, slow, ocular search of unwashed, carefully collected and handled rock specimens is crucially imperative as well.

Sr. Lange shows that the Paraná habitus differed in no respect apparently from the ostracode-scolecodont facies so often reported elsewhere. The existence of ostracodes in the Paraná Devonian is also an important discovery of the author. Their presence precludes the argument that exceptional bottom conditions must have prevailed to account for the extraordinary array of complete mouthpart sets herein described. If ostracodes were the chief scavengers and principal villains responsible for the dispersal of the worm mouthparts, as several writers have suggested, they are equally suspect in Brazil as elsewhere. The writer does point out, however, the possibility of exceptional chemical conditions in the Ponta Grossa muds which account for the exceptional preservation of the largely calcareous mandibular elements of the otherwise largely chitinous mouthparts. These are usually known only from molds, if preserved at all.

Before proceeding further with the elaboration of additional "form" categories in the scolecodonts (and conodonts?), or comparably complex organs or organisms, it might be well for all of us to assimilate well such disturbing factors as these: 1) Scolecodont mouthparts, like those of modern marine worms, are often highly complex structures, each part of which might be (and often has been) the basis for a "form" genus; 2) it often happens that neither the entire buccal assemblage of modern worms, nor the individual parts, show valid specific traits, although the complete organization is usually generic; 3) although the mouthparts of toothed worms are bilaterally disposed, they are commonly quite asymmetrical, the right and left elements thus not being the mirror images of each other; (apparently this discrepancy between equivalent paired parts may in certain mouths attain to as much as "form" genus value!) 4) in modern worms, and also among the complete mouthpart sets from Paraná, there is such individual variation as easily to match "form" species differences among fossils; 5) Modern worms apparently moult their hard mouthparts several times during ontogeny; the morphologic, paleotaxonomic and biogenetic (if any) significance of this fact is not yet evaluated; 6) there is a disconcertingly close similarity between certain of the buccal elements (apparently not always homologous) in quite unrelated genera of modern marine worms; this similarity is sufficiently close as to make their assignment to the same "form" genus certain; 7) sufficiently large collections of the dissociated scolecodont buccal elements will probably show the same intimate intergradation through a wide range of variation seen in the Paraná suite; species differentiation under such circumstances is unusually artificial and profitless. Finally, it might be well for us to examine the masterly treatment of the problems afforded by these complex fossil organs at the hands of our Brazilian colleague.

KENNETH E. CASTER
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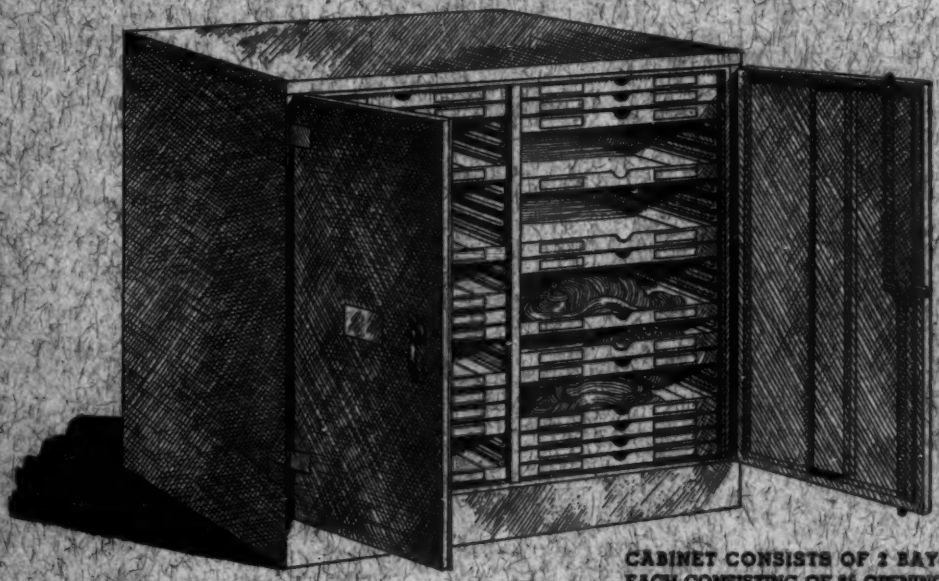

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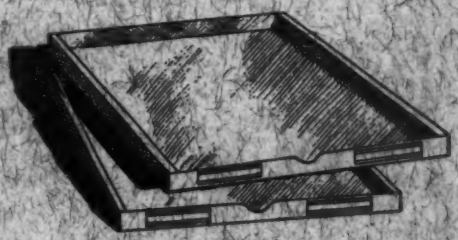

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